I-17 CORRIDOR PROFILE STUDY

SR 101L TO I-40

ADOT Work Task No. MPD 072B-14

ADOT Contract No. 11-013164

Draft Working Paper 6: Solution Evaluation and Prioritization

March 2016

PREPARED FOR:

Arizona Department of Transportation

PREPARED BY:

AECOM

This report was funded in part through grants from the Federal Highway Administration, U.S. Department of Transportation. The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data, and for the use or adaptation of previously published material, presented herein. The contents do not necessarily reflect the official views or policies of the Arizona Department of Transportation or the Federal Highway Administration, U.S. Department of Transportation. This report does not constitute a standard, specification, or regulation. Trade or manufacturers' names that may appear herein are cited only because they are considered essential to the objectives of the report. The U.S. government and the State of Arizona do not endorse products or manufacturers.

Table of Contents

List of Tables

List of Figures

Appendix

1 INTRODUCTION

The Arizona Department of Transportation (ADOT) is the lead agency for this corridor profile study of Interstate 17 (I-17) between SR 101L in Phoenix and I-40 in Flagstaff. This study will look at key performance measures relative to the I-17 corridor, and use those as a means to prioritize future improvements in areas that show critical deficiencies. The intent of the corridor profile program, and of the Planning to Programming (P2P) process, is to conduct performance-based planning to identify areas of need and make the most efficient use of available funding to provide an efficient transportation network.

1.1 Corridor Overview

The Arizona Sun Corridor is one of eleven megapolitan areas in the United States, defined as a conglomeration of two or more intertwined metropolitan areas. The Sun Corridor megapolitan extends from Nogales to Prescott, and is similar to Indiana in area and population. The Sun Corridor is one of the fastest growing areas in the country, with I-17 playing a key role in the transportation infrastructure of its northern portion, contributing to its economic success.

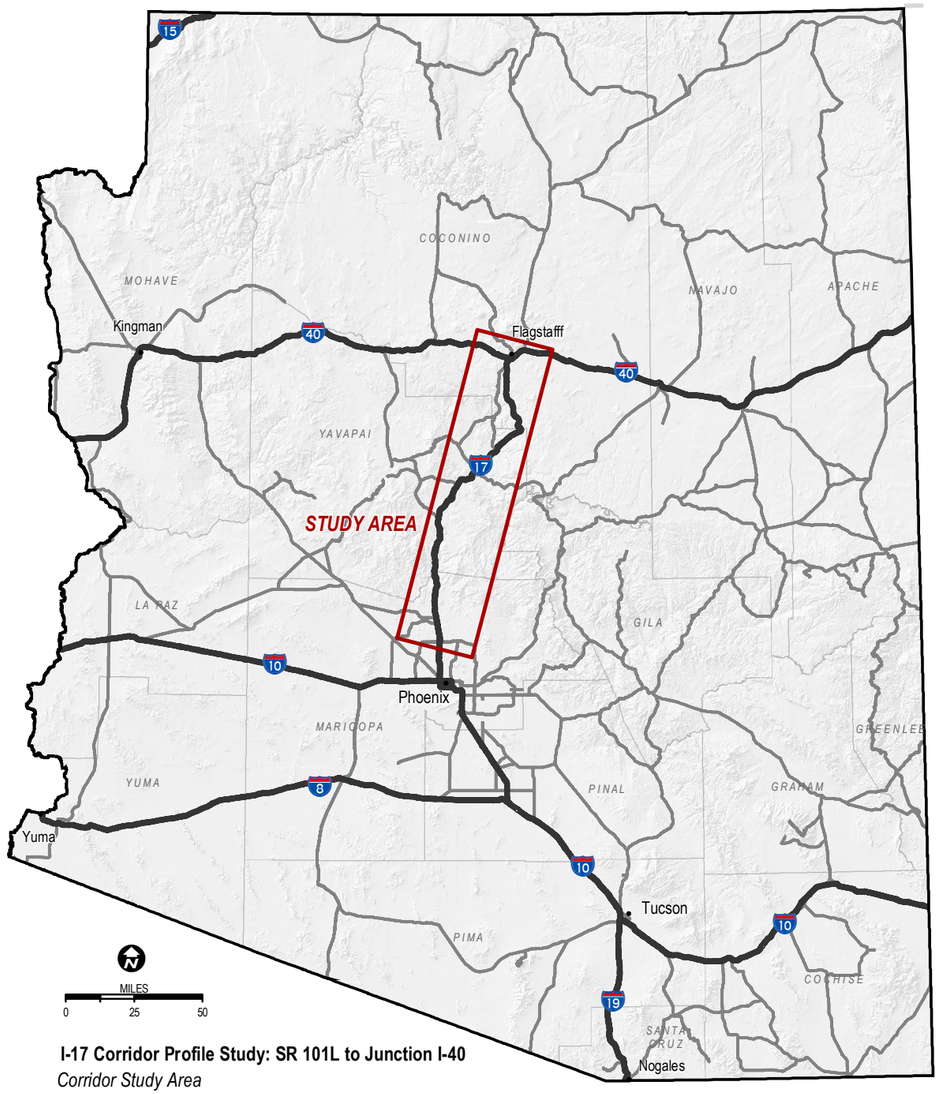
I-17 provides the most direct and fastest link between Phoenix (and I-10) and Flagstaff (and I-40) (**Figure 1**). I-17 provides a principal road link for national and international traffic from Phoenix Sky Harbor International Airport to Prescott, the Verde Valley, Sedona, Flagstaff, the Grand Canyon, and the Navajo and Hopi nations (**Figure 2**). This study builds on earlier planning efforts in developing and applying a performance-based process for prioritizing improvements to meet present and future needs in the corridor.

1.2 Corridor Study Purpose

ADOT seeks to identify a new corridor planning approach to develop strategies and tools that incorporate life-cycle cost analysis and risk assessment to measure system performance. This Corridor Profile Study, along with similar studies of other key routes, will develop a new process to:

- Inventory past improvement recommendations.
- Assess the existing performance based on quantifiable performance measures.
- Propose various solutions to improve corridor performance.
- Identify specific projects that can provide quantifiable benefits in relation to the performance measures.
- Recommend strategic projects for future consideration in the P2P programming process

Figure 1: Study Location Map



I-17 Corridor Profile Study: SR 101L to Junction I-40
Corridor Study Area

1.3 Corridor Study Objective

The objective of this study is to identify a recommended set of potential projects for consideration in future construction programs, derived from a transparent, defensible, logical, and replicable process.

1.4 Working Paper Objectives

The objective of Working Paper #6 is to document the evaluation of the strategic solutions (projects) identified for the I-17 Corridor. This evaluation will include a Life-Cycle Cost Analysis (LCCA), Benefit Cost Analysis (BCA), and a risk based performance effectiveness evaluation of each recommendation to determine the amount of benefit to the performance scores each project produces. The result of this evaluation will be a prioritized list of recommendations for the I-17 corridor.

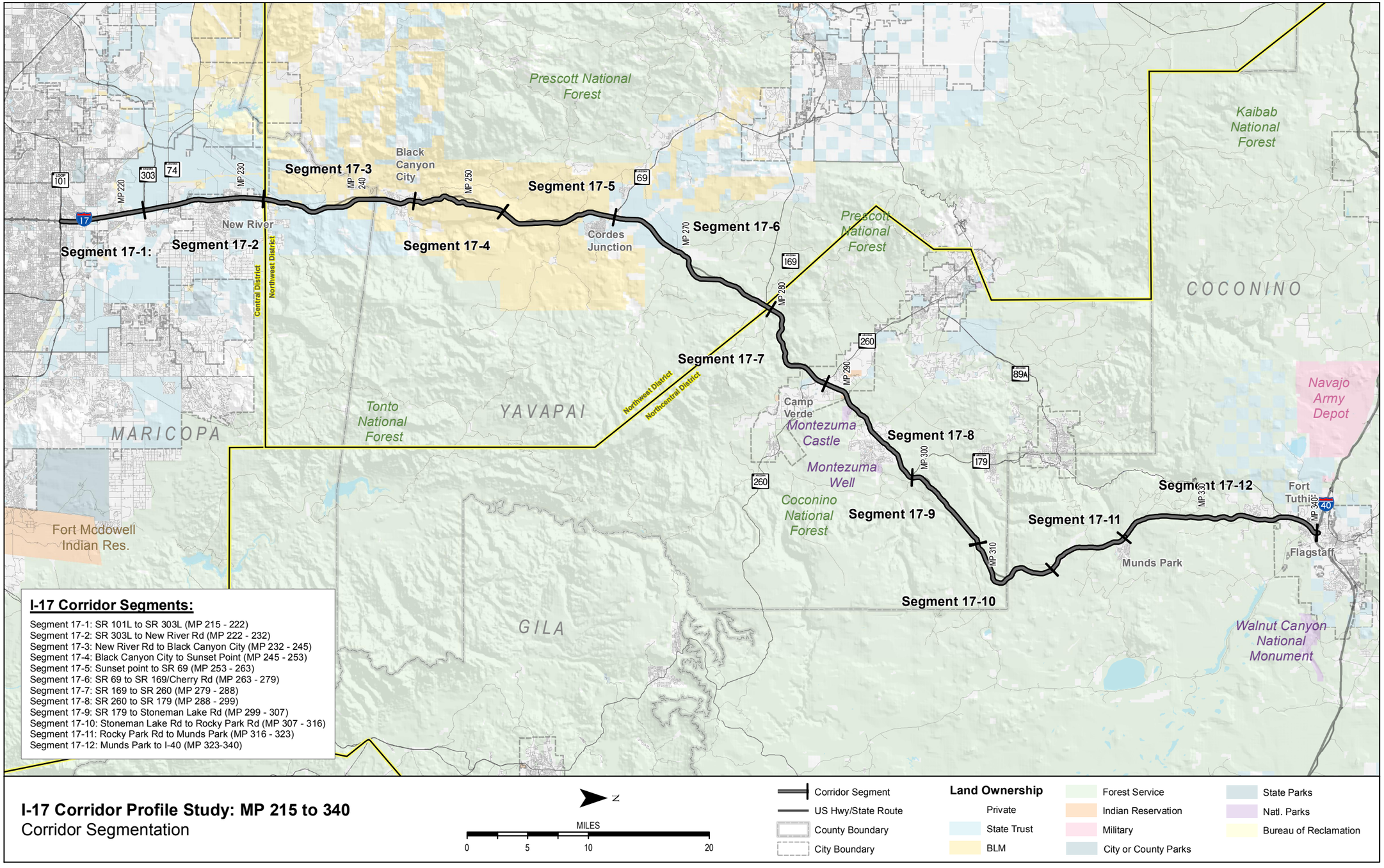
1.5 Study Location and Corridor Segments

The I-17 Corridor is 125 miles long, from SR 101L (Milepost [MP] 215.0) to I-40 (MP 340.0). The corridor has been divided into twelve distinct segments based on regionally significant intersecting routes, changes in topography, or natural or man-made landmarks along the corridor. The shortest segment is seven miles long and the longest, seventeen miles. Corridor Segments have been described in **Table 1** below, and shown on a map in **Figure 2**.

Table 1: Corridor Segmentation

Segment #	Segment Description	Character Description
Segment 1	SR101L to SR 303L (MP 215.0 to MP 222.0)	Segment 1 is generally urban/fringe-urban in nature while Segment 2 is generally rural in nature. Both are within the urbanized limits of the Phoenix Metropolitan Area in Maricopa County. Segment 1 includes six interchanges and Segment 2 includes six interchanges.
Segment 2	SR 303L to New River Road (MP 222.0 to MP 232.0)	
Segment 3	New River Road to Black Canyon City (MP 232.0 to MP 245.0)	Segment 3 is generally rural in nature, includes three interchanges, and spans both Maricopa and Yavapai Counties
Segment 4	Black Canyon City to Sunset Point Rest Area (MP 245.0 to MP 253.0)	Segment 4 is rural in nature, includes significant changes in topography, two interchanges, and is within Yavapai County.
Segment 5	Sunset Point Rest Area to SR 69 (MP 253.0 to MP 263.0)	Segment 5 is rural in nature, includes changes in topography, three interchanges, and is located within Yavapai County.
Segment 6	SR 69 to SR 169 (MP 263.0 to MP 279.0)	Segment 6 is rural in nature, passes through generally rolling terrain, includes two interchanges, and is located within Yavapai County.
Segment 7	SR 169 to SR 260 (MP 279.0 to MP 288.0)	Segment 7 goes through significant topography and elevation changes, is rural in nature, includes two interchanges, and is within Yavapai County.
Segment 8	SR 260 to SR 179 (MP 288.0 to MP 299.0)	Segment 8 passes through gradual elevation changes, is rural in character, includes three interchanges, and is located within Yavapai County.
Segment 9	SR 179 to Stoneman Lake Road (MP 299.0 to MP 307.0)	Segment 9 is rural in nature, includes changes in topography, one interchange, and is located within Yavapai County.
Segment 10	Stoneman Lake Road to Rocky Park Road (MP 307.0 to MP 316.0)	Segment 10 is rural in nature, includes changes in topography, one interchange, and spans both Yavapai and Coconino Counties.
Segment 11	Rocky Park Road to Munds Park Road (MP 316.0 to MP 323.0)	Segment 11 is rural in nature, includes three interchanges, and is located within Coconino County.
Segment 12	Munds Park Road to I-40 (MP 323.0 to MP 340.0)	Segment 12 transitions from a rural setting to a fringe-urban setting, includes four interchanges, is located within Coconino County, and extends into the City of Flagstaff.

Figure 2: Project Vicinity/Segmentation Map



2 CANDIDATE SOLUTION EVALUATION PROCESS

Candidate Solutions identified in Working Paper #5 will be evaluated in multiple ways including a Life Cycle Cost or Benefit Cost Analysis (where applicable), Risk Analysis, and a Performance Effectiveness Analysis. The methodology and approach to this analysis is described below. **Figure 3** illustrates the candidate solution evaluation process.

Life Cycle Cost Analysis or Benefit Costs Analysis – All pavement and bridge candidate solutions have multiple options, rehabilitate the area of need, or fully reconstruct the issue area or structure. These options will be evaluated through a life cycle cost analysis (LCCA) to determine the best approach for each location where a pavement or bridge solution is recommended. The LCCA could eliminate options from further consideration and will identify which options should be carried forward for further evaluation.

Any mobility, safety, or freight strategic issue area that resulted in multiple independent candidate solutions will be evaluated through a benefit cost analysis (BCA) to determine which solutions should be eliminated or carried forward. After the LCCA and BCA, the remaining options will be advanced to the Performance Effectiveness Evaluation.

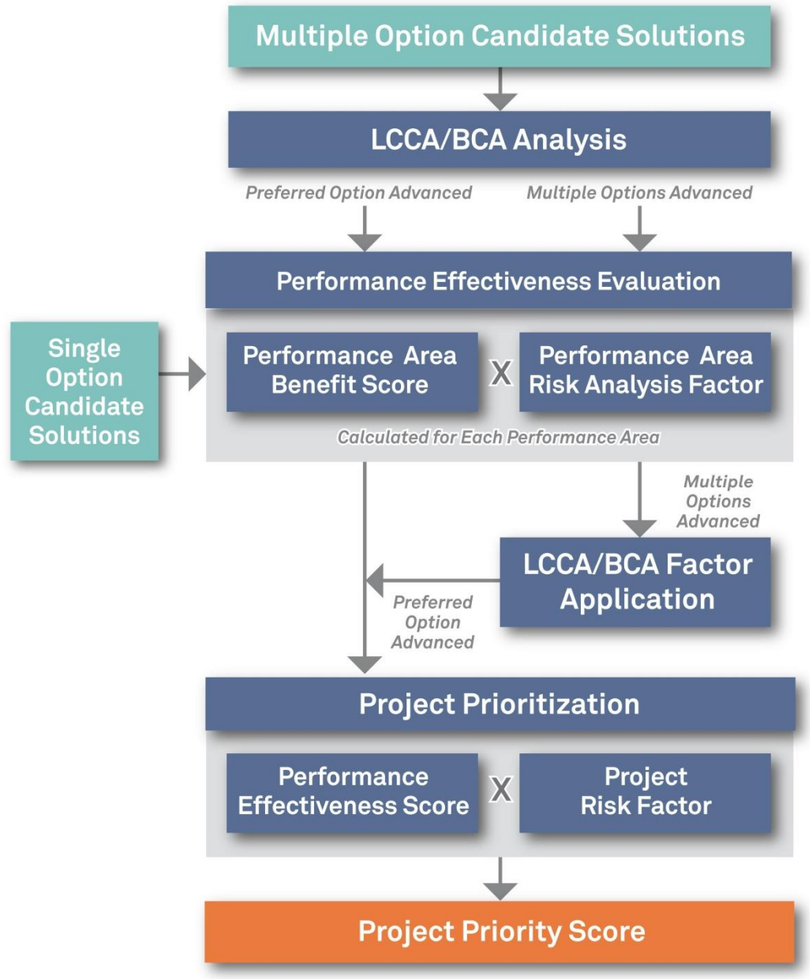
Performance Effectiveness Evaluation – After the LCCA and BCA processes are complete, all remaining candidate solutions will be evaluated based on their performance effectiveness. This process will include determining a performance effectiveness score based on how much each solution impacts the existing Performance and Needs scores for each project segment. This evaluation will also include a Performance Area Risk Evaluation to help differentiate between similar solutions based on factors that are not directly addressed in the performance system.

Risk Analysis – All candidate solutions that are advanced through the Performance Effectiveness Evaluation will also be evaluated through a Risk Analysis process. This process will examine the risk of not implementing a recommended solution in terms of overall corridor performance. The results of this analysis will be combined with the Performance Effectiveness scores to determine the highest priority solutions in the corridor.

The highest ranking strategic solutions will be compared to other projects nominated through the ADOT Planning to Programming Link (P2P) process.

Strategic solutions are not intended to be a substitute or replacement for traditional ADOT project development processes where various ADOT technical groups and districts develop candidate projects for consideration in the performance-based programming in the P2P Link process. Rather, these strategic investments are intended to complement ADOT's traditional project development processes with non-traditional projects to address performance needs in one or a combination of the five performance areas of Pavement, Bridge, Mobility, Safety, and Freight. Strategic investments developed for the I-17 corridor will be considered along with other candidate projects in the ADOT programming process.

Figure 3: Solution Evaluation Process



3 CANDIDATE SOLUTION EVALUATION

The principal objective of the corridor profile study is to identify strategic solutions (investments) that are performance-based to ensure that available funding resources are used to maximize the performance of the State's key transportation corridors. The corridor profile process is intended to provide input to the P2P process and will assign strategic solutions to one of the three investment categories: Preservation, Modernization, or Expansion.

The performance system and performance needs previously documented in Working Papers #2 and #4, respectively, served as a foundation for developing strategic solutions for corridor preservation, modernization, and expansion.

Strategic solutions are not intended to recreate or replace results from normal programming processes. However, they should address elevated levels (high or medium) of need and focus on investments in Modernization projects to optimize current infrastructure. Ideally, strategic solutions should address overlapping needs and reduce costly repetitive maintenance. In addition, they should provide a measureable benefit (benefit/cost ratio, risk, LCCA, performance system, etc.)

Strategic solutions were derived from previous reports, field reviews, ADOT staff input, observable trends in the performance data, current standards, national and local best practices, and engineering judgement, as documented in Draft Working Paper #5. **Table 2** contains the candidate strategic solutions for the corridor. Cost estimates for each candidate solution are contained in Appendix A.

Following the distribution of Draft Working Paper #5 (Strategic Solutions), several modifications were made to the Performance System (Draft Working Paper #2). These modifications resulted in revisions to the Needs Assessment (Draft Working Paper #4) and the resulting strategic solutions (Draft Working Paper #5). Therefore, the candidate solutions shown in Table 2 may differ from those previously shown in Draft Working Paper #5.

Table 2: Candidate Solutions

Solution #	Name	Milepost	Description	Investment Category (P/M/E)
CS17.1	Table Mesa Rd TI	MP 236	Re-profile southbound roadway	M
CS17.2	Black Canyon Hill	MP 245-251	Option A – Construct northbound climbing lane Option B – Construct reversible lane(s) Option C – Shoulder running for northbound traffic Enhance roadside design (replace guardrail with concrete barrier) Enhance delineation (pavement marking, delineators, rumble strips) Install curve warning signs and chevrons Excavate/grade cut slopes to improve sight distance Install dynamic speed feedback system on southbound roadway near MP 248 and 251	M
CS17.3	Sunset Point	MP 252-253	Construct/extend parallel entrance and exit ramps at Sunset Point TI Install roadway weather information system (RWIS) Install dynamic wind warning system	M
CS17.4	Badger Springs Climbing Lane	MP 256-260 (NB)	Construct northbound climbing lane	M
CS17.5	Orme Road Safety Improvements	MP 269-274 (SB)	Increase skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) Enhance delineation (striping, delineators, rumble strips) Install curve warning signs and chevrons Install dynamic speed feedback system	M
CS17.6	McGuireville TI Bridge	MP 293	Option A – Repair/rehabilitate McGuireville TI bridge and construct new southbound exit ramp Option B – Replace McGuireville TI bridge	P M
CS17.7	Middle Verde Road Safety Improvements	MP 290-292 (NB)	Increase skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) Enhance delineation (striping, delineators, rumble strips) Install curve warning signs and chevrons Install dynamic speed feedback system Install CCTV on existing DMS located at MP 289	M
CS17.8	Dry Beaver Creek Southbound Climbing Lane	MP 292-294 (SB)	Construct southbound climbing lane	M

Solution #	Name	Milepost	Description	Investment Category (P/M/E)
CS17.9	Dry Beaver Creek Northbound Climbing Lane	MP 294-298 (NB)	Construct northbound climbing lane	M
CS17.10	McGuireville Rest Area Safety Improvements	MP 295-298 (SB)	Increase skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) Enhance delineation (striping, delineators, rumble strips) Install curve warning signs and chevrons Install dynamic speed feedback system Install CCTV on existing DMS located at MP 297.4	M
CS17.11	SR179 TI	MP 299	Construct/extend parallel entrance and exit ramps at SR179 TI Install solar powered LED lighting at ramp gores	M
CS17.12	Hog Tank Canyon Northbound Climbing Lane	MP 299-305 (NB)	Construct northbound climbing lane Install new DMS at MP 303.4 with CCTV	M
CS17.13	Hog Tank Canyon Southbound Safety Improvements	MP 300-302 (SB)	Increase skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) Enhance delineation (striping, delineators, rumble strips) Install curve warning signs and chevrons Install dynamic speed feedback system Install solar-powered LED lighting Excavate/grade cut slopes to improve sight distance	M
CS17.14	Rattlesnake Canyon Safety Improvements	MP 306-307 (NB)	Increase skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) Enhance delineation (striping, delineators, rumble strips) Install curve warning signs and chevrons Install dynamic speed feedback system Construct/extend northbound parallel entrance ramp at Stoneman Lake TI Install CCTV near MP 306.5	M
CS17.15	Red Hill Scenic Overlook Safety Improvements	MP 311-313 (SB)	Increase skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) Enhance delineation (striping, delineators, rumble strips) Install curve warning signs and chevrons Install solar powered LED lighting at ramp gores Install dynamic speed feedback system Install CCTV near MP 312.3 Construct/extend southbound parallel exit and entrance ramp at scenic overlook	M
CS17.16	Woods Canyon Climbing Lane	MP 316-317 (SB)	Construct southbound climbing lane	M
CS17.17	Woods Canyon Bridges	MP 317	Realign roadway and construct new bridges over Woods Canyon with de-icing system Enhance delineation (striping, delineators, rumble strips) Excavate/grade cut slopes and remove trees to reduce roadway shading Install roadway weather information system (RWIS) near Rocky Park TI or Woods Canyon	M
CS17.18	Kachina Village Pavement	MP 326-334 (NB) MP 339-340 (NB) MP 339-340 (SB)	Option A – Rehabilitate pavement Option B – Replace pavement	P M
CS17.19	Airport Rd TI Bridge	MP 337	Option A – Rehabilitate Airport Rd TI bridge Option B – Replace Airport Rd TI bridge	P M

3.1 Life-Cycle Cost Analysis and Benefit-Cost Analysis

A life-cycle cost analysis (LCCA) or benefit-cost analysis (BCA) was conducted for any candidate solutions that contain multiple options. The intent of the LCCA and BCA was to determine which options warrant further investigation and eliminate options that would not be considered strategic. An LCCA was performed on Pavement and Bridge candidate solutions while a BCA was performed on Mobility, Safety, or Freight candidate solutions (where required).

Life-Cycle Cost Analysis

LCCA is an economic analysis that compares cost streams over time and presents the results in a common measure, the present value of all future costs. The cost stream occurs over an analysis period that is long enough to provide a reasonably fair comparison among alternatives that may differ significantly in scale of improvement actions over shorter time periods. For both bridge and pavement LCCA, the costs are focused on agency (ADOT) costs for corrective actions to meet the objective of keeping the bridge or pavement serviceable over a long period of time.

LCCA is performed to provide a more complete holistic perspective on asset performance and agency costs over the life of an investment stream. This approach helps ADOT look beyond initial and short term costs which often dominate the considerations in transportation investment decision making and programming.

For the bridge LCCA, three basic strategies were analyzed that differ in timing and scale of improvement actions to maintain the selected bridges, as described below:

- Bridge replacement (large upfront cost but small ongoing costs afterwards)
- Bridge rehabilitation until replacement (moderate upfront costs then small to moderate ongoing costs until replacement)
- On-going repairs until replacement (low upfront and ongoing costs until replacement)

The bridge LCCA model developed for the Corridor Profile Studies reviews the characteristics of the candidate bridges including bridge ratings and deterioration rates to develop the three improvement strategies (full replacement, rehabilitation until replacement, and repair until replacement). Each strategy consists of a set of corrective actions that contribute to keeping the bridge serviceable over the analysis period. Cost and effect of these improvement actions on the bridge condition are essential parts of the model. Other considerations in the model include bridge age, elevation, pier height, length to span ratio, skew angle, and substandard characteristics such as shoulders and vehicle clearance. The following assumptions are included in the bridge LCCA model:

- The bridge LCCA will only address the structural condition of the bridge and will not address other issues or costs.
- The bridge will require replacement near the end of the its 75 year service life regardless of current condition.
- The bridge elevation, pier height, skew angle, and length to span ratio can affect the replacement and rehabilitation costs.
- The current and historical ratings were used to estimate a rate of deterioration for each candidate bridge.
- Following bridge replacement, repairs will be needed every 20 years.
- Different bridge repair and rehabilitation strategies have different costs, expected service life, and benefit to the bridge rating.
- The net present value of future costs will be discounted at 3%.
- If the LCCA evaluation recommends rehabilitation or repair, the project will not be considered strategic and the rehabilitation or repair will be addressed by normal programming processes.
- Because this LCCA is conducted at a planning level, and due to variabilities in costs and improvement strategies, the LCCA net present value results that are within 15% should be considered equally. In such a case, the project should be carried forward as a strategic replacement project – more detailed scoping will confirm if replacement or rehabilitation is needed.

Based on the candidate solutions presented in Table 2, LCCA was conducted on two bridges on the I-17 corridor. A summary of this analysis is shown in **Table 3.** Additional information regarding the LCCA is contained in Appendix B.

The LCCA approach to pavement was very similar to the process used for bridges. For the pavement LCCA, three basic strategies are analyzed that differ in timing and scale of improvement actions to maintain the selected pavement, as described below:

- Pavement replacement (large upfront cost but small ongoing costs afterwards)
- Pavement major rehabilitation until replacement (moderate upfront costs then small to moderate ongoing costs until replacement)
- Pavement minor rehabilitation until replacement (low upfront and ongoing costs until replacement)

The pavement LCCA model developed for the Corridor Profile Studies reviews the characteristics of the candidate paving locations including the historical rehabilitation frequency to develop potential improvement strategies (full replacement, major rehabilitation until replacement, minor rehabilitation until replacement, for either concrete or asphalt, as applicable). Each strategy consists of a set of corrective actions that contribute to keeping the pavement serviceable over the analysis period. The following assumptions are included in the pavement LCCA model:

- The pavement LCCA will only address the condition of the pavement and will not address other issues or costs.
- The historical pavement rehabilitation frequencies at each location were used to estimate the future rehabilitation frequencies.

- Different pavement replacement and rehabilitation strategies have different costs and expected service life.
- The net present value of future costs will be discounted at 3%.
- If the LCCA evaluation recommends rehabilitation, the project will not be considered strategic and the rehabilitation will be addressed by normal programming processes.
- Because this LCCA is conducted at a planning level, and due to variabilities in costs and improvement strategies, the LCCA net present value results that are within 15% should be considered equally. In such a case, the project should be carried forward as a strategic replacement project – more detailed scoping will confirm if replacement or rehabilitation is needed.

Based on the candidate solutions presented in Table 2, LCCA was conducted for two pavement projects on the I-17 corridor. A summary of this analysis is shown in **Table 3.** Additional information regarding the LCCA is contained in Appendix B.

As shown in Table 3, the following conclusions were determined based on the LCCA:

- Rehabilitation or repair was determined to be the most effective approach for the candidate solutions listed below and these locations do not have other Needs. Therefore, it is assumed that these needs and solutions will be addressed by normal programming processes and these candidate solutions will be dropped from further consideration.
  - Airport Rd TI Bridge (CS17.19)
  - Kachina Village Pavement (CS17.18)(NB MP 326-334)
  - Kachina Village Pavement (CS17.18)(MP 339-340)
- Rehabilitation or repair was determined to be the most effective approach for the candidate solutions listed below. However, these locations have other Needs so multiple candidate solutions will be carried forward for further consideration.
  - McGuireville Rd TI Bridge (CS 17.06)

Table 3: LCCA Results

Candidate Solution	Present Value at 3% Discount Rate ($)			Ratio of Present Value Compared to Lowest Present Value			Other Needs	Results
	Replace	Rehab	Repair	Replace	Rehab	Repair		
McGuireville Rd TI Bridge (CS17.06)	$3,288,000	$3,990,400	$2,460,200	1.34	1.62	1.00	Yes	Not strategic as a stand-alone project; carry forward for further evaluation with other Needs
Airport Rd TI Bridge (CS17.19)	$3,623,200	$3,021,800	$3,055,800	1.20	1.00	1.01	No	Not strategic as a stand-alone project and no other Needs – no further evaluation
Kachina Village Pavement (CS 17.18) (NB MP 326-334)	$37,515,100	$30,865,500	$31,251,700	1.22	1.00	1.01	No	Not strategic as a stand-alone project and no other Needs – no further evaluation
Kachina Village Pavement (CS17.18) (MP 339-340)	$9,325,400	$7,754,200	$8,120,200	1.20	1.00	1.05	No	Not strategic as a stand-alone project and no other Needs – no further evaluation

Benefit Cost Analysis

In a BCA, the benefits and costs of a project are estimated and compared to each other to determine if the benefits exceed the costs. This is accomplished by quantifying the benefits in dollars and using a ratio (benefits divided by costs) to make the comparison. If the resulting ratio is greater than 1.0, then the benefits are greater than the costs. The higher the ratio is above 1.0, the more the benefits exceed the costs. For the Corridor Profile Studies, the BCA computes agency costs and user benefits over time and presents the results in a common measure, the present value in dollars. A BCA may be performed to compare options for Mobility and Safety solutions (when applicable).

A number of assumptions were used in the analysis, including:

- Analysis period is 2020 - 2039, or 20 full years of operation
- Construction takes place over 2020-2021
- All values are in 2015 dollars
- Approximately $9.7 million (in 2015) for fatality and $2.6 million (in 2015) for incapacitating injury, based on USDOT guidance
- Value of time is approximately $28 per hour (in 2015) for trucks and $19 per hour (in 2015) for autos, based on USDOT guidance
- Auto occupancy rate of 1.55 people (2009 National Household Travel Survey)
- The net present value of future costs will be discounted at 3%
- Trucks are 100% business use and autos are 100% personal use
- O&M costs are 1% (per year) of initial capital costs starting in 2025
- Residual value in 2039 is pro-rated based on 60 year service life (and discounted at 3%)
- Emission rates based on US Environmental Protection Agency's (EPA) guidance
- Value of emissions based on USDOT guidance

Based on the candidate solutions presented in Table 2, BCA was conducted for one location on the I-17 corridor. A summary of the analysis is shown in **Table 4**. Additional information regarding the BCA is contained in Appendix B.

Table 4: BCA Results

	20 Year Analysis Period (2020 -2039) Values stated in 2015 $M		
	CS 17.2 – A Climbing Lane	**CS17.2 – B 2 Reversible Lanes**	**CS17.2 – C Shoulder Running**
Costs			
Capital Costs	$ 45.02	$ 130.30	$ 44.62
O&M Costs	$ 4.85	$14.02	$ 4.80
Total Costs	***$ 49.87***	***$ 144.32***	***$ 49.42***
Benefits			
Safety Savings	$ 90.75	$ 101.89	$ 74.18
Emissions Savings	$ 0.13	$ 0.67	$ 0.13
CO2 Reductions	$ 0.39	$ 2.09	$ 0.38
Incident Delay Avoided	$ 18.88	$ 113.41	$ 18.40
Travel Time Savings	$ 0.06	$ 0.10	$ 0.06
Residual Effects			
Residual Value	$ 11.38	$ 32.94	$ 11.28
Total Benefits	***$ 121.60***	***$ 251.12***	***$ 104.43***
BC Ratio	**2.44**	**1.74**	**2.11**
Results	Carry forward due to highest BCA	Carry forward to verify with Performance Effectiveness Score	Eliminate from further consideration

As shown in Table 4, Option A (Climbing Lane) has the highest BCA (over 2.0) primarily due to the safety benefits. Therefore, Option A will be carried forward for further evaluation. Option C (Shoulder Running) has the second highest BCA. However, this option has a cost and benefits similar to Option A but would only provide mobility benefits during the limited times that shoulder running would be activated. Therefore, it was eliminated from further consideration. Option B (Reversible Lanes) scored the lowest BCA but was still above 1.0. In addition, Option B has roughly double the benefit of Option A. This option has been previously recommended for implementation in a recent Design Concept Report and therefore will be carried forward for further evaluation.

3.2 Performance Effectiveness Evaluation

After the LCCA and BCA processes were complete, all remaining candidate solutions were evaluated based on their performance effectiveness. This process included determining a performance effectiveness score based on how much each solution impacts the existing Performance and level of Need scores for each project segment. The results of this evaluation will be combined with the results of a risk analysis to determine a Performance Effectiveness Score. The objectives of the Performance Effectiveness Evaluation include:

- Measure of benefit in performance system versus cost of solution
- Include risk factors to help differentiate between similar solutions
- Applicable to each Performance Area that is effected by the candidate solution
- Accounts for Emphasis Areas that were identified for the corridor

The Performance Effectiveness Evaluation includes the following steps:

- Estimate the post-project performance for each of the five performance areas (Bridge, Pavement, Safety, Mobility, and Freight)
- Use the post-project performance scores to calculate a post-project level of Need for each of the five performance areas (Bridge, Pavement, Safety, Mobility, and Freight)
- Compare the pre-project level of Need to the post-project level of Need to determine the reduction in level of Need (potential project benefit) for each of the five performance areas (Bridge, Pavement, Safety, Mobility, and Freight)
- Calculate performance area risk weighting factors for each of the five performance areas (Bridge, Pavement, Safety, Mobility, and Freight)
- Using the reduction in level of Need (benefit) and risk weighting factors, calculate the Performance Effectiveness Score

For each Performance Area, a slightly different approach was used to estimate the post-project performance. This process was based on the following assumptions:

- Pavement:
  - The IRI rating would decrease (to 30 for replacement or 45 for rehabilitation)
  - The Cracking rating would decrease (to 0 for replacement or rehabilitation)
- Bridge:
  - The structural ratings would increase (+1 for repair, +2 for rehabilitation, or increase to 8 for replacement)
  - The bridge sufficiency rating would increase (+10 for repair, +20 for rehabilitation, or increase to 98 for replacement)
- Mobility:
  - Additional lanes would increase the capacity and therefore revise the Mobility Index and two secondary measures

  - Other improvements (ramp metering, parallel ramps, variable speed limits) will also increase the capacity (to a lesser extent than additional lanes) and therefore revise the Mobility Index and two secondary measures
  - Changes in the Mobility Index (due to increased capacity) would have a direct effect on the TTI secondary measure
  - Changes in the Mobility Index (due to increased capacity) and Safety Index (due to crash reductions) would have a direct effect on the PTI secondary measure
  - Changes in the Safety Index (due to crash reductions) would have direct effect on the Closure Extent secondary measure
- Safety:
  - Crash Modification Factors were developed and applied to estimate the reduction in crashes (see Appendix C)
- Freight:
  - Changes in the Mobility Index (due to increased capacity) and Safety Index (due to crash reductions) would have a direct effect on the Freight Index and the TPTI secondary measure
  - Changes in the Mobility Index (due to increased capacity) would have a direct effect on the TTTI secondary measure
  - Changes in the Safety Index (due to crash reductions) would have direct effect on the Closure Duration secondary measure

The Performance Area Risk Assessment is intended to develop a numeric risk weighting factor for each of the five Performance Areas (Bridge, Pavement, Safety, Mobility, and Freight). This risk assessment addresses other considerations for each Performance Area that are not directly included in the Performance System. A risk weighting factor is calculated for each candidate solution based on the specific characteristics at the project location. For example, the Pavement Risk Factor is based on factors such as the elevation, daily traffic volumes, and amount of truck traffic. Additional information regarding the Performance Area Risk Assessment is included in Appendix D.

Following the calculation of the reduction in level of Need (benefit) and the Performance Area Risk Factors, these values were used to calculate the Performance Effectiveness Score. In addition, the reduction in level of Need in each Emphasis Area was also included the in the Performance Effectiveness Score. The performance Effectiveness Score (PES) can be described as follows:

PES = (Sum of all Risk Factored Benefit Scores + Sum of all Risk Factored Emphasis Area Scores) x 100 / Cost x VMT / 10,000

Where,

Risk Factored Benefit Score = Reduction in Segment-Level Need (benefit) x Performance Area Risk Weighting Factor (calculated for each Performance Area)

Risk Factored Emphasis Area Score = Reduction in Corridor-Level Need x Performance Area Risk Factors x Emphasis Area Factor (calculated for each Emphasis Area)

Cost = estimate cost of candidate solution in $millions

VMT = vehicle miles travelled at location of candidate solution based on current (2014) daily volume and length of project

The resulting PES values are shown in **Table 5**. Additional information regarding the Performance Effectiveness Scoring is included in Appendix E.

Table 5: Initial Performance Effectiveness Scores

Candidate Solution #	Candidate Solution Name	Milepost Location	Estimated Cost ($ million)	Risk Factored Benefit Score					Risk Factored Emphasis Area Scores		Total Factored Benefit Score	VMT/10,000	Performance Effectiveness Score
				Pavement	Bridge	Safety	Mobility	Freight	Safety	Mobility			
CS17.1	Table Mesa Rd TI	236	2.37	0.00	0.00	0.00	0.00	2.33	0.00	0.00	2.34	0.83	81
CS17.2 - A	Black Canyon Hill	245-251	51.42	0.00	1.75	3.02	5.99	6.41	0.29	0.12	17.16	17.81	609
CS17.2 - B	Black Canyon Hill	245-251	148.82	0.00	1.44	3.35	8.67	14.71	0.42	0.20	28.17	17.81	345
CS17.3	Sunset Point	252-253	4.63	0.00	0.00	1.71	0.39	2.24	0.13	0.00	4.46	2.97	286
CS17.4	Badger Springs Climbing Lane	NB 256-260	14.9	0.00	0.00	0.51	1.31	0.018	0.05	0.06	1.95	5.43	71
CS17.5	Orme Road Safety Improvements	SB 269-274	4.52	0.00	0.00	2.31	0.99	1.96	0.50	0.00	5.76	5.05	644
CS17.6 - A	McGuireville TI Bridge	293	5.85	0.00	1.09	0.00	0.000	2.14	0.00	0.00	3.23	1.12	62
CS17.6 - B	McGuireville TI Bridge	293	18.32	0.00	2.19	0.00	0.000	2.14	0.00	0.00	4.32	2.24	59
CS17.7	Middle Verde Road Safety Improvements	NB 290-292	1.92	0.00	0.00	1.22	0.03	0.02	0.20	0.00	1.47	2.24	172
CS17.8	Dry Beaver Creek Southbound Climbing Lane	SB 292-294	9.35	0.00	0.00	0.00	0.08	0.00	0.00	0.01	0.09	2.24	3
CS17.9	Dry Beaver Creek Northbound Climbing Lane	NB 294-298	14.90	0.00	0.000	1.19	0.25	0.01	0.20	0.04	1.69	4.48	51
CS17.10	McGuireville Rest Area Safety Improvements	SB 295-298	2.83	0.00	0.00	3.06	0.02	0.02	0.50	0.00	3.59	3.36	426
CS17.11	SR179 TI	299	4.97	0.00	0.00	1.43	0.03	0.03	0.23	0.00	1.71	1.12	38
CS17.12	Hog Tank Canyon Northbound Climbing Lane	NB 299-305	23.05	0.00	0.00	0.08	1.67	0.62	0.04	0.07	2.48	5.69	61
CS17.13	Hog Tank Canyon Southbound Safety Improvements	SB 300-302	4.52	0.00	0.00	5.66	0.03	0.40	0.65	0.00	6.74	1.90	283
CS17.14	Rattlesnake Canyon Safety Improvements	NB 306-307	2.15	0.00	0.00	3.48	0.50	0.90	0.41	0.00	5.29	0.95	233
CS17.15	Red Hill Scenic Overlook Safety Improvements	SB 311-313	6.33	0.00	0.00	0.52	0.03	0.35	0.35	0.00	1.24	1.60	32
CS17.16	Woods Canyon Climbing Lane	SB 316-317	5.65	0.00	0.00	0.06	0.05	0.00	0.01	0.01	0.13	0.81	2
CS17.17	Woods Canyon Bridges	316.5 - 317.5	37.06	1.52	0.00	3.52	0.04	0.05	0.27	0.00	5.40	1.62	24

Following the LCCA and BCA, some options were eliminated from further consideration. However, in some cases (as shown in Table 5), some candidate solutions still contain multiple options. This may occur if the LCCA or BCA results were very close (within approximately 15%), or if a location had multiple needs. In these cases, a secondary step may be required to select a single option. If the LCCA (or BCA) and PES both show the same option is more effective, then no further analysis is needed and the single option is carried forward. If the LCCA (or BCA) and the PES show different results, the LCCA (or BCA) results would be used to calculate a factor that would be used to adjust the PES. The adjusted PES would be used to identify the best performing option.

The following conclusions were determined based on this process:

- The BCA analysis of Black Canyon Hill (CS17.02) showed that Option A (Climbing Lane) had a higher (better) BCA score than Option B (Reversible Lanes). The PES showed the same result. Therefore, only Option A was carried forward for prioritization.
- The LCCA analysis of the McGuireville Road TI Bridge (CS17.06) indicated that repair was the most feasible solution (based on structural condition). The PES showed the same result. Therefore, repair (with other improvements) will be carried forward for prioritization.

Following the completion of this step, the remaining Candidate Solutions and their Performance Effectiveness Scores were carried forward for prioritization.

4 CANDIDATE SOLUTION PRIORTIZATION

Following the calculation of the Performance Effectiveness Scores (PES), an additional step was taken to develop the prioritized list of projects. A risk probability and consequence analysis was conducted to develop a project-level risk weighting factor. This risk analysis is a numeric scoring system to help address the risk of not implementing a solution based on the likelihood and severity of the performance failure. **Figure 4** shows the risk matrix that was used to develop the risk weighting factors.

Figure 4: Risk Matrix

		Severity/Consequence				
		Insignificant	Minor	Significant	Major	Catastrophic
Frequency/Likelihood	Very Rare	Low	Low	Low	Moderate	Major
	Rare	Low	Low	Moderate	Major	Major
	Seldom	Low	Moderate	Moderate	Major	Severe
	Common	Moderate	Moderate	Major	Severe	Severe
	Frequent	Moderate	Major	Severe	Severe	Severe

Using the risk matrix in Figure 4, numeric values were assigned to each category of frequency and severity. The higher the risk, the higher the numeric factor that was assigned. The risk weight for each area of the matrix was calculated by multiplying the severity factor times the frequency factor. These numeric factors are shown in **Figure 5**.

Figure 5: Numeric Risk Matrix

			Severity/Consequence				
			Insignificant	Minor	Significant	Major	Catastrophic
		Weight	1.00	1.05	1.10	1.15	1.20
Frequency/Likelihood	Very Rare	1.00	1.00	1.05	1.10	1.15	1.20
	Rare	1.05	1.05	1.10	1.16	1.21	1.26
	Seldom	1.10	1.10	1.16	1.21	1.27	1.32
	Common	1.15	1.15	1.21	1.27	1.32	1.38
	Frequent	1.20	1.20	1.26	1.32	1.38	1.44

Using the values in Figure 5, risk weighting factors were calculated for each of the four risk categories (low, moderate, major, and severe). These values are simply the average of the values in Figure 5 that fall within each category. The resulting average risk weighting factors are:

Low	Moderate	Major	Severe
1.07	1.18	1.24	1.36

The risk weighting factors listed above were assigned to the five performance areas as follows:

- Safety = 1.36
  - The Safety performance area quantifies the likelihood of fatal or incapacitating crashes; therefore, it was assigned the highest (Severe) risk weight.
- Bridge = 1.24
  - The Bridge performance area focuses on the structural adequacy of the bridges. A failure may result in crashes (that would not be addressed in the Safety performance area) or traffic being detoured for long periods of time resulting in significant travel time increases; therefore, it was assigned the Major (1.24) risk weighting factor.
- Mobility and Freight = 1.18
  - The Mobility and Freight performance areas focus on capacity and congestion. Failure in either of these performance areas would result in increased travel times but would not have significant effect on safety (crashes) that would not already be addressed in the Safety performance area; therefore, they were assigned the Moderate (1.18) risk weighing factor.
- Pavement = 1.07
  - The Pavement performance area focuses on the ride quality of the pavement. Failure in this performance area would likely be a spot location that would not dramatically effect drivers beyond what is already captured in the Safety performance area.

The benefit in each performance area was calculated for each candidate solution as part of the Performance Effectiveness Evaluation. Using this information, and the risk factors listed above, a weighted (based on benefit) project-level numeric risk factor was calculated for each candidate solution. For example, a solution that has 50% of its benefit in Safety and 50% of its benefit in Mobility would have a risk factor of 1.27 (0.50 x 1.18 + 0.50 x 1.36 = 1.27). These risk factors were applied directly to the Performance Effectiveness Scores shown in Table 5. Candidate Solutions were prioritized based on these results, as shown in **Table 6**. Additional information regarding the prioritization scores is contained in Appendix F.

Table 6: Prioritized Project List

Rank	Candidate Solution #	Candidate Solution Name	Milepost Location	Estimated Cost ($ million)	Performance Effectiveness Score	Risk Factor	Prioritization Score
1	CS17.05	Orme Rd Safety Improvements	SB 269-274	4.52	644	1.27	816
2	CS17.02	Black Canyon Hill Option A - Northbound Climbing Lane	NB 245-251	51.42	609	1.22	744
3	CS17.10	McGuireville Rest Area Safety Improvements	SB 295-298	2.83	426	1.36	579
4	CS17.13	Hog Tank Canyon Southbound Safety Improvements	SB 300-302	4.52	283	1.35	381
5	CS17.03	Sunset Point TI	252-253	4.63	286	1.25	358
6	CS17.14	Rattlesnake Canyon Safety Improvements	NB 306-307	2.15	233	1.31	306
7	CS17.07	Middle Verde Road Safety Improvements	NB 290-292	1.92	172	1.35	232
8	CS17.01	Table Mesa TI	236	2.37	81	1.18	96
9	CS17.04	Badger Springs Climbing Lane	NB 256-260	14.9	71	1.23	88
10	CS17.06	McGuireville TI Option A – Repair bridge and construct new SB exit ramp	293.25-293.75	5.85	62	1.21	75
11	CS17.12	Hog Tank Canyon Northbound Climbing Lane	NB 299-305	23.05	61	1.19	73
12	CS17.09	Dry Beaver Creek Northbound Climbing Lane	NB 294-298	14.9	51	1.33	68
13	CS17.11	SR 179 TI	299	4.97	39	1.35	52
14	CS17.15	Red Hill Scenic Overlook Safety Improvements	SB 311-313	6.33	32	1.31	41
15	CS17.17	Woods Canyon - Realign roadway	316.5 - 317.5	37.06	24	1.28	30
16	CS17.08	Dry Beaver Creek Southbound Climbing Lane	SB 292-294	9.35	3	1.18	3
17	CS17.16	Woods Canyon Climbing Lane	SB 316-317	5.65	2	1.28	2

Table 6 prioritizes the strategic solutions recommended as a result of this corridor profile study. These solutions will increase the performance of the I-17 corridor across a majority of the performance areas. Solutions that address multiple performance areas tend to score higher in this process. Several projects on the corridor scored high on the Performance Effectiveness Scale due to overlapping benefits in Safety, Mobility, and Freight.

For example:

- Several of the top scoring projects include safety improvements at specific locations which would likely reduce the incidence of run off the road type vehicle crashes that often result in fatal and serious injuries.
- Segment 4 of the I-17 corridor showed mobility, safety, and freight needs and had the highest composite need score. The second ranked project would enhance the safety, mobility, and freight performance in this location, thus resulting in benefits across all three performance areas.
- The two lowest scoring projects occur in locations that do not exhibit mobility needs but were rather based on safety needs. However, at the specific locations of the projects there is not a high frequency of fatal and serious crashes which results in a low benefit score.

The table above prioritizes the strategic solutions (derived from a performance based process) that can be nominated for consideration in the ADOT P2P process along with other project nominations.

5 NEXT STEPS

The strategic investments recommended in this study are not intended to be a substitute or replacement for traditional ADOT project development processes where various ADOT technical groups and districts develop candidate projects for consideration in the performance-based programming in the P2P Link process. Rather, these strategic investments are intended to complement ADOT's project development processes with non-traditional projects to address performance needs in one or a combination of the five performance areas of Pavement, Bridge, Mobility, Safety, and Freight. Strategic investments developed for the I-17 corridor will be considered along with other candidate projects in the ADOT statewide programming process.

The concluding step in the corridor profile studies will be to produce a final report for the Round 1 studies (I-19, I-17, and I-40 west) that summarizes working papers 1 through 6. Additional final reports for rounds 2 and 3 will be completed following the full development of those working papers.

Upon completion of all three rounds, the results will be incorporated into a summary document comparing all corridors and is expected to provide a performance-based review of statewide needs.

Appendix A

Candidate Solution Cost Estimates

Appendix A Candidate Solution Cost Estimates

	SOLUTION	QUANTITY	UNIT	UNIT COST	TOTAL CONSTRUCTION COST
CS17.01	**Table Mesa Rd TI**				
	Re-profile roadway (1 direction)	1	Mile	$2,130,000	$2,130,000
				CONSTRUCTION SUBTOTAL	**$2,100,000**
				3% Preliminary Eng	**$60,000**
				10% Design	**$210,000**
				TOTAL	**$2,370,000**
CS17.02	**Black Canyon Hill**				
	Option A - climbing lane (northbound)				
	Northbound climbing lane	6	Mile	$6,600,000	$39,600,000
	Replace Bumble Bee NB bridge	7150	SF	$280	$2,002,000
	Replace guardrail - (length assumed)	8	Mile	$286,000	$2,288,000
	Install curve warning signs - southbound	10	Each	$2,500	$25,000
	Enhance delineation - southbound	6	Mile	$54,500	$330,000
	Install chevrons - southbound	2.5	Mile	$40,500	$100,000
	Cut side slopes - southbound (length assumed)	5000	LF	$200	$1,000,000
	Install dynamic speed feedback system	2	Each	$55,000	$110,000
				CONSTRUCTION SUBTOTAL	**$45,500,000**
				3% Preliminary Eng	**$1,370,000**
				10% Design	**$4,550,000**
				TOTAL	**$51,420,000**
	Option B - reversible lanes (2)				
	Construct Reversible lanes (2 lanes for 6 miles)	12	lane-Mile	$10,560,000	$126,700,000
	Replace Bumble Bee SB bridge	7700	SF	$280	$2,156,000
	Replace guardrail - (length assumed)	8	Mile	$286,000	$2,288,000
	Install curve warning signs - southbound	10	Each	$2,500	$25,000
	Enhance delineation - southbound	6	Mile	$54,500	$330,000
	Install chevrons - southbound	2.5	Mile	$40,500	$100,000
	Install dynamic speed feedback system	2	Each	$55,000	$110,000
				CONSTRUCTION SUBTOTAL	**$131,700,000**
				3% Preliminary Eng	**$3,950,000**
				10% Design	**$13,170,000**
				TOTAL	**$148,820,000**

	SOLUTION	QUANTITY	UNIT	UNIT COST	TOTAL CONSTRUCTION COST
	Option C - shoulder running (northbound)				
	Northbound shoulder running	6	Mile	$6,864,000	$41,200,000
	Replace guardrail - (length assumed)	8	Mile	$286,000	$2,288,000
	Install curve warning signs - southbound	10	Each	$2,500	$25,000
	Enhance delineation - southbound	6	Mile	$54,500	$330,000
	Install chevrons - southbound	2.5	Mile	$40,500	$100,000
	Cut side slopes - southbound (length assumed)	5000	LF	$200	$1,000,000
	Install dynamic speed feedback system	2	Each	$55,000	$110,000
				CONSTRUCTION SUBTOTAL	**$45,100,000**
				3% Preliminary Eng	**$1,350,000**
				10% Design	**$4,510,000**
				TOTAL	**$50,960,000**
CS17.03	**Sunset Point (MP 252-253)**				
	Extend ramp	4	Each	$979,000	$3,916,000
	Install RWIS	1	Each	$132,000	$132,000
	Install wind warning system	1	Each	$88,000	$88,000
				CONSTRUCTION SUBTOTAL	**$4,100,000**
				3% Preliminary Eng	**$120,000**
				10% Design	**$410,000**
				TOTAL	**$4,630,000**
CS17.04	**Badger Springs Climbing Lane (MP 256-260)**				
	Southbound climbing lane	4	Mile	$3,300,000	$13,200,000
				CONSTRUCTION SUBTOTAL	**$13,200,000**
				3% Preliminary Eng	**$400,000**
				10% Design	**$1,300,000**
				TOTAL	**$14,900,000**
CS17.05	**Orme Road Safety Improvements (MP 269-274)**				
	Total 5 miles; 5 curves; 2.5 miles of curves; 2.5 miles of tangent				
	Increase skid resistance	2.5	Mile	$1,470,000	$3,675,000
	Enhance delineation	2.5	Mile	$54,500	$136,000
	Install curve warning signs	5	Each	$2,500	$13,000
	Install chevrons	2.5	Mile	$40,500	$101,000
	Install speed feedback system	2	Each	$55,000	$110,000
				CONSTRUCTION SUBTOTAL	**$4,000,000**
				3% Preliminary Eng	**$120,000**
				10% Design	**$400,000**
				TOTAL	**$4,520,000**

	SOLUTION	QUANTITY	UNIT	UNIT COST	TOTAL CONSTRUCTION COST
CS17.06	**McGuireville TI Bridge**				
	Option A - rehab bridge and construct new ramp				
	Construct new exit ramp	1	Each	$1,610,000	$1,610,000
	New bridge over Dry Beaver Creek	7000	SF	$280	$1,960,000
	Additional earthwork	1	Each	$1,000,000	$1,000,000
	Rehabilitate McGuireville bridge	9000	SF	$25	$230,000
				CONSTRUCTION SUBTOTAL	**$5,000,000**
			3%	Preliminary Eng	**$150,000**
			10%	Design	**$500,000**
	R/W	2.5	Acre	$80,000	**$200,000**
				TOTAL	**$5,850,000**
	Option B - replace bridge				
	Cost to replace TI from previous DCR	1	Lump Sum	$16,000,000	**$16,000,000**
				CONSTRUCTION SUBTOTAL	**$16,000,000**
			3%	Preliminary Eng	**$480,000**
			10%	Design	**$1,600,000**
	R/W	3.0	Acre	$80,000	**$240,000**
				TOTAL	**$18,320,000**
CS17.07	**Middle Verde Road Safety Improvements (MP 290-292)**				
	Total 2 miles; 3 curves; 1 miles of curves; 1 miles of tangent				
	Increase skid resistance	1	Mile	$1,470,000	$1,470,000
	Enhance delineation	1	Mile	$54,500	$55,000
	Install curve warning signs	3	Each	$2,500	$8,000
	Install chevrons	1	Mile	$40,500	$41,000
	Install speed feedback system	1	Each	$55,000	$55,000
	Install CCTV	1	Each	$55,000	$55,000
				CONSTRUCTION SUBTOTAL	**$1,700,000**
			3%	Preliminary Eng	**$50,000**
			10%	Design	**$170,000**
				TOTAL	**$1,920,000**
CS17.08	**Dry Beaver Creek Southbound Climbing Lane (MP 292-294)**				
	Southbound climbing lane	2	Mile	$3,300,000	$6,600,000
	Widen Dry Beaver Creek SB	4280	SF	$390	$1,669,200
				CONSTRUCTION SUBTOTAL	**$8,270,000**
			3%	Preliminary Eng	**$250,000**
			10%	Design	**$830,000**
				TOTAL	**$9,350,000**
CS17.09	**Dry Beaver Creek Northbound Climbing Lane (MP 294-298)**				
	Northbound climbing lane	4	Mile	$3,300,000	$13,200,000
				CONSTRUCTION SUBTOTAL	**$13,200,000**
			3%	Preliminary Eng	**$400,000**
			10%	Design	**$1,300,000**
				TOTAL	**$14,900,000**

	SOLUTION	QUANTITY	UNIT	UNIT COST	TOTAL CONSTRUCTION COST
CS17.10	**McGuireville Rest Area Safety Improvements (MP 295-298)**				
	Total 3 miles; 5 curves; 1.5 miles of curves; 1.5 miles of tangent				
	Increase skid resistance	1.5	Mile	$1,470,000	$2,205,000
	Enhance delineation	1.5	Mile	$54,500	$82,000
	Install curve warning signs	5	Each	$2,500	$13,000
	Install chevrons	1.5	Mile	$40,500	$61,000
	Install speed feedback system	2	Each	$55,000	$110,000
	Install CCTV	1	Each	$55,000	$55,000
				CONSTRUCTION SUBTOTAL	**$2,500,000**
			3%	Preliminary Eng	**$80,000**
			10%	Design	**$250,000**
				TOTAL	**$2,830,000**
CS17.11	**SR 179 TI**				
	Extend ramp	4	Each	$979,000	$3,916,000
	Lighting	20	Each	$22,000	$440,000
				CONSTRUCTION SUBTOTAL	**$4,400,000**
			3%	Preliminary Eng	**$130,000**
			10%	Design	**$440,000**
				TOTAL	**$4,970,000**
CS17.12	**Hog Tank Canyon Northbound Climbing Lane (MP 299-305)**				
	Northbound climbing lane	6	Mile	$3,300,000	$19,800,000
	New DMS with CCTV	1	Each	$605,000	$605,000
				CONSTRUCTION SUBTOTAL	**$20,400,000**
			3%	Preliminary Eng	**$610,000**
			10%	Design	**$2,040,000**
				TOTAL	**$23,050,000**
CS17.13	**Hog Tank Canyon Southbound Safety Improvements (MP 300-302)**				
	Total 2 miles; 3 curves; 1.5 miles of curves; 0.5 miles of tangent				
	Increase skid resistance	1.5	Mile	$1,470,000	$2,205,000
	Enhance delineation	0.5	Mile	$54,500	$27,000
	Install curve warning signs	3	Each	$2,500	$8,000
	Install chevrons	1.5	Mile	$40,500	$61,000
	Install speed feedback system	2	Each	$55,000	$110,000
	Install lighting	53	Each	$22,000	$1,166,000
	Excavate/grade cut clopes	2000	LF	$200	$400,000
				CONSTRUCTION SUBTOTAL	**$4,000,000**
			3%	Preliminary Eng	**$120,000**
			10%	Design	**$400,000**
				TOTAL	**$4,520,000**

	SOLUTION	QUANTITY	UNIT	UNIT COST	TOTAL CONSTRUCTION COST
CS17.14	**Rattlesnake Canyon Safety Improvements (MP 306-307)**				
	Total 1 miles; 1 curve; 0.5 miles of curves; 0.5 miles of tangent				
	Increase skid resistance	0.5	Mile	$1,470,000	$735,000
	Enhance delineation	0.5	Mile	$54,500	$27,000
	Install curve warning signs	1	Each	$2,500	$3,000
	Install chevrons	0.5	Mile	$40,500	$20,000
	Install speed feedback system	1	Each	$55,000	$55,000
	Extend ramp	1	Each	$979,000	$979,000
	Install CCTV	1	Each	$55,000	$55,000
				CONSTRUCTION SUBTOTAL	**$1,900,000**
				3% Preliminary Eng	**$60,000**
				10% Design	**$190,000**
				TOTAL	**$2,150,000**
CS17.15	**Red Hill Scenic Overlook Safety Improvements (MP 311-313)**				
	Total 2 miles; 2 curve; 1.5 miles of curves; 0.5 miles of tangent				
	Increase skid resistance	1.5	Mile	$1,470,000	$2,205,000
	Enhance delineation	0.5	Mile	$54,500	$27,000
	Install curve warning signs	2	Each	$2,500	$5,000
	Install chevrons	1.5	Mile	$40,500	$61,000
	Install speed feedback system	2	Each	$55,000	$110,000
	Extend ramp	2	Each	$979,000	$1,958,000
	Install lighting	53	Each	$22,000	$1,166,000
	Install CCTV	1	Each	$55,000	$55,000
				CONSTRUCTION SUBTOTAL	**$5,600,000**
				3% Preliminary Eng	**$170,000**
				10% Design	**$560,000**
				TOTAL	**$6,330,000**
CS17.16	**Woods Canyon Climbing Lane (MP 316-317)**				
	Southbound climbing lane	1	Mile	$4,950,000	$4,950,000
				CONSTRUCTION SUBTOTAL	**$5,000,000**
				3% Preliminary Eng	**$150,000**
				10% Design	**$500,000**
				TOTAL	**$5,650,000**
CS17.17	**Woods Canyon Bridges**				
	Realign roadway - both directions	2	Mile	$6,510,000	$13,020,000
	Additional earthwork (based on previous DCR)	1	Each	$10,000,000	$10,000,000
	Install RWIS	1	Each	$132,000	$132,000
	Remove trees - one direction	1	Mile	$440,000	$440,000
	New Bridges (w/ de-icing)	22400	SF	$413	$9,240,000
				CONSTRUCTION SUBTOTAL	**$32,800,000**
				3% Preliminary Eng	**$980,000**
				10% Design	**$3,280,000**
				TOTAL	**$37,060,000**

	SOLUTION	QUANTITY	UNIT	UNIT COST	TOTAL CONSTRUCTION COST
CS17.18	**Kachina Village Pavement**				
	Replace pavement (AC) - one direction	8	Mile	$3,170,000	$25,360,000
	Replace pavement (PCCP) - both directions	2	Mile	$3,810,000	$7,620,000
				CONSTRUCTION SUBTOTAL	**$33,000,000**
				3% Preliminary Eng	**$990,000**
				10% Design	**$3,300,000**
				TOTAL	**$37,290,000**
CS17.19	**Airport Rd TI Bridge**				
	Option A - rehab bridge				
	Rehabilitate Airport Rd bridge	7280	SF	$140	$1,020,000
				CONSTRUCTION SUBTOTAL	**$1,000,000**
				3% Preliminary Eng	**$30,000**
				10% Design	**$100,000**
				TOTAL	**$1,130,000**
	Option B - replace bridge				
	Cost to replace TI from previous DCR	1	Lump Sum	$16,900,000	**$16,900,000**
				CONSTRUCTION SUBTOTAL	**$17,000,000**
				3% Preliminary Eng	**$510,000**
				10% Design	**$1,700,000**
				TOTAL	**$19,210,000**

Appendix B

Life-Cycle Cost Analysis and Benefit-Cost Analysis

Appendix B Life Cycle Cost and Benefit Cost Analysis

LIFE CYCLE COST ANALYSIS

Introduction

This section presents the results of a Life Cycle Cost Analysis (LCCA) for selected bridges on I-17. The LCCA is used to assess the potential for bridges to advance as strategic projects in the set of corridor recommendations, either on their own as a bridge-only strategic project, or combined with other needs associated with the roadway segment within which the bridge is located. The format of this section is as follows:

- How bridge improvements work now
- What is a life cycle cost analysis and why is it performed
- I-17 bridges identified for LCCA (and why)
- The I-17 corridor bridge profile LCCA model
- Results of I-17 LCCA and how used in the Corridor Profile Study
- Next steps

How Bridges Are Cared For Now

ADOT's essential objective is to keep each bridge in working order (rating of 4 or higher) in an economical manner. Key considerations involved in achieving this objective include the traffic volumes and role of the roadway facility for which the bridge is a feature, the rate of deterioration of the bridge and its major components or subsystems, the user impact of restrictions or detours should the bridge not perform adequately, and the total funding available for bridge maintenance, repair, rehabilitation, and replacement over a time period. Bridges have a long design life (typically 75 years) so they are seldom completely replaced unless a larger improvement project on the associated roadway is required to add capacity or make other operational or safety improvements.

In a perfect world with adequate funding, ADOT's bridge managers would apply "optimal" or most cost-effective (i.e. economical) corrective actions to maintain a bridge's performance at 4 or higher. In the less than perfect real world with funding often in short supply, less expensive but sometimes less economical actions are applied to keep the bridges in service due to overall funding limitations. This approach tends to minimize ADOT costs in the short term but can contribute to increased costs in the longer term. If occasional short term funding limitations are followed by adequate funding levels, this adverse consequence can generally be remedied. But if funding limitations become the norm then the avoidable future cost increases can become a serious liability for the agency. The bridge Life Cycle Cost Analysis has been proposed as part of this Corridor Profile Study in order to identify cases where spending more money sooner may provide a more economical strategy over time to keeping a bridge in working order. It also provides an opportunity to consider if other non-bridge needs on the associated roadway may be combined with bridge needs to develop a solution strategy that accomplishes multiple objectives with reduced interruption to the traveling public.

Life Cycle Cost Analysis – What and Why

Life Cycle Cost Analysis is an economic study that compares the cost stream over time of a set of improvement actions from different alternatives and presents the results in a common measure, the present value of all future costs. The alternatives are focused on achieving the same or very similar objectives. The cost stream occurs over an analysis period that is long enough to provide a reasonably fair comparison among alternatives that may differ significantly in scale of improvement actions over shorter time periods. For this bridge life cycle cost analysis, the costs are focused on agency (ADOT) costs for corrective actions to meet the objective of keeping a bridge serviceable over a long period of time. LCCA often also includes user costs (i.e. benefits) but those were omitted for this initial analysis except in a qualitative manner. The focus has remained on ADOT agency costs.

The reason for performing life cycle cost analysis is to provide a more complete holistic perspective on asset performance and agency costs over the life of an investment stream. This approach helps ADOT look beyond initial and short term costs which often dominate the considerations in transportation investment decision making and programming.

In this bridge life cycle cost analysis, three basic strategies are analyzed that differ in timing and scale of improvement actions to maintain the selected bridges. These strategies are immediate bridge replacement (large up-front cost but small ongoing costs afterwards), immediate rehabilitation until replacement (moderate up-front costs then small to moderate ongoing costs until replacement), and ongoing repairs until replacement (low up-front and ongoing costs until replacement).

Bridges Selected for I-17 LCCA

Two bridges were selected for LCCA for I-17. They were selected due to their current ratings and their historical ratings. The bridges selected for LCCA analysis are:

- Airport Road TI (#632)
- McGuireville (#652)

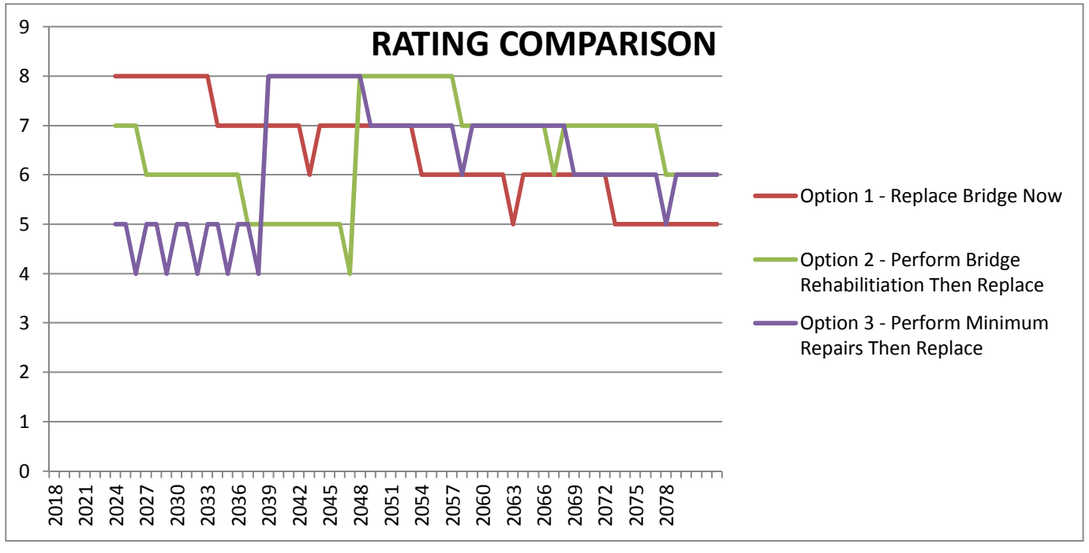
Both bridges carry crossroads over I-17 at traffic interchanges.

The CPS Bridge LCCA Model Overview

The bridge LCCA model for the Corridor Profile Studies reviews the characteristics of the selected bridges including bridge ratings and deterioration rates to develop three improvement strategies as outlined earlier – full replacement, rehabilitation until replacement, and repair until replacement. Each strategy consists of a set of corrective actions that contribute to keeping the bridge serviceable over the analysis period. Cost and effect of these improvement actions on the bridge condition are essential parts of the model. Other considerations in the model include bridge age, elevation, pier height, length to span ratio, skew angle, and substandard characteristics such as shoulders and vehicle clearance.

The effect on the bridge performance over time for each strategy is shown on Figure 1 for illustration from one of the I-17 bridges, the McGuireville TI bridge which carries Cornville Road over I-17. That chart shows the bridge rating in each year over the analysis period by improvement strategy. Similar charts were generated for the other I-17 LCCA bridge.

Figure 1: Bridge Condition Rating for I-17 McGuireville Bridge by Year by Improvement Strategy



This bridge hits the 75 year replacement limit in 2036. The three strategies have very close average rating over the analysis period (6.3 to 6.5). Thus the three strategies have similar condition outcomes for the bridge over time.

The cost of the set of improvement actions in each strategy that resulted in the McGuireville ratings chart above is shown in Table 1. Agency costs are shown in total undiscounted and discounted (present value at 3%) 2015 $ over the 65 year analysis period ending in 2080.

Table 1: Cost of Future Improvement Strategies for McGuireville Bridge

Cost of Strategy: 2021-2080, 2015 $1,000		
OPTION	**UNDISCOUNTED**	**PV at 3%**
Option 1 (Replace)	$4,199	$3,288
Option 2 (Rehab)	$6,829	$3,990
Option 3 (Repair)	$4,693	$2,460

In this case, the Option 1 (full replacement immediately) is the lowest cost in undiscounted dollars, but the Option 3 repair strategy (followed by replacement when the bridge life hits 75 years) is the lowest cost in discounted dollars, which is a better metric to use. Similar calculations were completed for the other I-17 LCCA bridge.

The next section of this chapter shows how the results are used in identifying candidate strategic bridge projects from the set of two bridges selected for LCCA, first looking at the bridges alone, then afterwards looking at the bridges in the context of the other needs on its associated roadway.

Life Cycle Cost Results

This section reviews the life cycle cost results from several perspectives. These are:

- undiscounted total ADOT costs over the analysis period
- discounted total ADOT costs over the analysis period
- how close the various strategies are
- combining bridge LCCA results with other needs on the connecting roadway

ADOT Future Costs by Bridge Strategy - Undiscounted

Table 2 summarizes the bridge life cycle cost results for the two I-17 bridges selected for this analysis for the three improvement strategies. The results are all in undiscounted 2015 dollars – i.e. no time value of money. The shading colors indicate the rank order of the costs with green as the lowest, yellow as second, and red as highest.

Table 2: Total Costs by Strategy by Bridge - Undiscounted 2015$

I-17 Bridge		
Item	Name	Number
1	Airport Rd (TI)	632
2	MGuireville	652

ADOT Future Costs: 2021-2080		
2015 $1,000 Undiscounted		
1-Replace	2-Rehab	3-Repair
$4,541	$5,312	$5,374
$4,199	$6,829	$4,693

Both bridges in all improvement strategy cases kept the bridge rating above 4 in all years.

The total cost of mitigation strategies for these bridges range from a low of $4.2 million to a high of $6.8 million over the analysis period. Full bridge replacement as soon as possible is the lowest cost strategy to keep both bridges at rating of 4 or higher over the analysis period in an economical manner. Full replacement immediately introduces a major corrective action up front followed by minimal minor repair actions over the remaining years of the analysis period. The Option 3 minimum repair strategy (until required end of life replacement) is second lowest for one of the bridges and just barely above Option 2 rehabilitation for the other.

ADOT Future Costs by Bridge Strategy – Present Value Costs (at 3% discount rate)

The time value of money was not considered in the previous section but is actually an important consideration. This section describes how discounting future investments affects the comparative results of the different bridge improvement strategies.

Table 3 shows the total cost for the same corrective actions as in Table2 except that the future expenditures are discounted to present value costs at a 3% annual rate. As with Table 2 the color shading indicates the rank order of the strategies. The order for discounted results is different than for the undiscounted values.

Table 3: Total Costs by Strategy by Bridge - Discounted 2015$

I-17 Bridge			ADOT Future Costs: 2021-2080		
			2015 $1,000 PV 3%		
Item	Name	Number	1-Replace	2-Rehab	3-Repair
1	Airport Rd (TI)	632	$3,623	$3,022	$3,056
2	MGuireville	652	$3,288	$3,990	$2,460

In this discounted perspective, the Option 3 repair strategy is the lowest cost for the McGuireville bridges. Option 2 rehabilitation is the lowest cost for Airport Road but just barely lower than Option 3 repair so those two strategies are essentially tied. Again the average bridge condition rating over the analysis period is similar in all three cases. These results reinforce the experience of ADOT Staff Bridge Group that replacing a bridge is a very rare event unless a related mobility or other need creates a larger project within which a full bridge replacement is called for. None of the bridges had Option 1 Replacement as the lowest cost strategy so none are identified as a candidate for a strategic bridge only project from this first examination.

Future Costs Present Value – Tolerance Band Around Lowest Cost Strategy

While the previous section looked at the LCCA results in pure rank order, this section examines “how close” the results and rankings are to see if there are differences among strategies that are small enough to be assumed a tie and thus possibly modify the interpretation of results.

A “tolerance” of 15% of the difference between strategies was established as a tie. This tolerance suggests that if the second lowest cost strategy is within 15% of the lowest cost and the second lowest cost is a more aggressive strategy than the lowest cost strategy, then the two strategies are essentially tied, and the designation goes to the more aggressive strategy. This test acknowledges the degree of uncertainty in the life cycle cost analysis.

Table 4: Percent Cost Above Next Lower Cost Strategy

I-17 Bridge			% Above Next Lower Value			
			Present Value 3%			% High
Item	Name	Number	1-Replace	2-Rehab	3-Repair	to Low
1	Airport Rd (TI)	632	18.6%	0.0%	1.1%	19.5%
2	MGuireville	652	33.7%	21.4%	0.0%	61.7%

Table 4 shows the same color ranking as the previous table for discounted total costs. For the second highest cost (yellow shading) and highest cost strategy (red shading), the percentage value shown is the percent that that strategy is above the next lower strategy (yellow to green, and red to yellow). If the yellow is 15% or less then it is tied with the green and the more aggressive strategy of the two is considered lowest cost. If the red value is 15% or less then the red strategy is considered a tie with the yellow strategy which may come into play in the “other needs” consideration presented later in this section. Finally the fourth percentage column on the right is the percent that the highest cost strategy (red shading) is above the lowest cost strategy (green shading). If this percentage is less than or equal to 15% and the highest cost strategy is more aggressive than the lowest or second cost strategy, then the revised designation of lowest cost strategy goes to the most aggressive strategy.

For I-17, the outright lowest discounted cost strategy was never Option 1 replacement, and furthermore this option was never within 15% of the lowest cost strategy. Thus again there is no nomination of a strategic bridge replacement project even after considering small differences in the results and rankings.

Other Considerations Combined with Life Cycle Cost Analysis

Other considerations in the reassessment of the LCCA results are focused on non LCCA results that may still tag a bridge for replacement due to a mobility need for widening (or lengthening) driven by other non LCCA factors such as adding a travel lane to increase roadway capacity. Other non-mobility needs that do not directly affect widening or lengthening may be considered as well.

The Airport Road TI bridge was not nominated for a strategic project earlier in this analysis. There are no other mobility, freight, or safety needs to examine in association with the bridge LCCA results. Thus this bridge is no longer advanced in the analysis either on its own or in combination with other needs.

The McGuireville TI bridge was not nominated for a strategic bridge project on its own. However there are other needs on the I-17 mainline that may warrant replacement.

MCGUIREVILLE TI (#652) / I-17 / MP 293.26

Bridge Information	
Bridge Deck Area (A225)	8995 SF
Year Built (N27)	1961
Exp Service Life	75 YR
Total Bridge Length (N49)	257 LF
Number of Spans (N45+N46)	4
Skew Angle (N34)	30 DEG
Average Elevation	3329 FT
Max Pier Height	23 FT
* Amount of Widening for Bridge	12 FT
Revised Deck Area (Bridge Replace)	12079 FT
**Scour Critical Rating (N113)	N/A

Deterioration Slope				
Item	Deterioration Line Equation			Year
	Slope =	Days	Years	Drop
Substr	y =	-0.000137x	-0.050x	20.00
Superstr	y =	-0.000996x	-0.364x	2.75
Deck	y =	-0.000268x	-0.098x	10.22

***Input 0 if no widening. Input should include widening on both sides of bridge if applicable.**

****If scour critical rating is 3 or lower, Option 2 should consider the implementation of scour countermeasures.**

Notes:

1. Widening is intended only to correct lane and/or shoulder width deficiencies. It is not intended for adding traffic capacity (i.e. adding general purpose lanes).

Cost Multipliers		
Elevation > 4000ft	3329	1.00
Pier Height > 30ft	23	1.00
Length to # span ratio	64.25	1.1
Skew > 30degrees	30.00	1.00

L to # Span Multiplier	
L/ # Span Ratio	Multiplier
=>100	1.00
=>60	1.10
<60	1.25

Skew Multiplier	
Skew	Multiplier
<30	1.00
=>30	1.10

Adjusted Bridge Replace Cost	
Base Bridge Replacement Cost (Per SF)	$280.00
Bridge Replacement Cost w/ Multipliers (Per SF)	$308.00

Elevation Multiplier	
Elev	Multiplier
<4000	1.00
=>4000	1.25

Pier H Multiplier	
Pier H	Multiplier
<30	1.00
=>30	1.10

User input cell

Only manipulate cell value after consulting with team

Bridge History (Inspections/As-builts)

Description	Category	Year
1. Bridge was originally constructed in 1961 (I 17-2(16)).		1961
2. Bridge has been impacted several times (posted vertical clearance is 14'-8"). Multiple repairs have been carried out:		
a. 1973, 17-2-503 - miscellaneous repair including deck/curb replacement over 114' and replacement of steel girder within limits.	Repair (Deck)	1973
	Replace (Supr - Stl)	
b. 1976, I-17-2-912 - steel girder repair including web straightening and flange replacement of existing steel girder.	Replace (Supr - Stl)	1976
c. 1984, I-17-2(918) - miscellaneous repair including deck/curb replacement over 114' and replacement of steel girder within limits.	Repair (Deck)	1984
	Replace (Supr - Stl)	
d. 2011, 017-B(002)A - weld/joint repairs with concrete deck repair/epoxy overlay.	Rehab (Deck Epoxy Overlay)	2011
	Repair (Supr - Stl)	
e. 2014, NH-IM-017-B(228)T - numerous repairs including flame straightening of girders (impact), cracked weld repairs, splice repairs, replacing missing bolts/nuts at diaphragms/stiffeners, missing nuts at anchor bolts, miscellaneous paint work, and deck joint replacement.	Repair (Deck)	2014
	Replace (Supr - Stl)	
3. Epoxy overlay in 2012 bridge inspection report was noted in good condition. Inspection reports have noted scrape marks likely due to impacts in the past.		
4. 2014 inspection report was completed prior to the latest set of as-builts noted; it's not immediately clear if all items have been addressed.		

Replace / Rehab / Repair Information

BRIDGE DECK

ITEM	DESCRIPTION	UNIT COST (Per SF)	LIFE (YRS)	RATING BENEFIT
Replace (Deck)	Full Deck Replacement	$154.00	25	Rating = 8
Rehab (Deck Concrete Overlay)	Overlay (Concrete)	$22.00	15	+ 2
Rehab (Deck Epoxy Overlay)	Overlay (Epoxy)	$11.00	10	+ 1
Repair (Deck)	Patch Spalls / Seal Cracks	$6.60	See Deterioration Slope	+ 0
Replace (Bridge)	Full Bridge Replacement	$308.00	75	Rating = 8
Repair (After Bridge Replace)	Patch Spalls / Seal Cracks	$6.60	20	+ 0
Repair (After Rehab)	Patch Spalls / Seal Cracks	$6.60	10	+ 0

SUPERSTRUCTURE - STEEL

ITEM	DESCRIPTION	UNIT COST (Per SF)	LIFE (YRS)	RATING BENEFIT
Replace (Supr - Stl)	Full SuperStr Replacement	$154.00	50	Rating = 8
Rehab (Supr - Stl)	Weld New Structural Components	$77.00	15	+ 2
Repair (Supr - Stl)	Weld Repair / Crack Relief	$11.00	See Deterioration Slope	+ 1

SUPERSTRUCTURE - CONCRETE

ITEM	DESCRIPTION	UNIT COST (Per SF)	LIFE (YRS)	RATING BENEFIT
Replace (Supr - Conc)	Full SuperStr Replacement	$154.00	50	Rating = 8
Rehab (Supr - Conc)	Replace Structural Component	$77.00	15	+ 2
Repair (Supr - Conc)	Patch Spalls / Seal Cracks	$11.00	See Deterioration Slope	+ 1
Replace (Bridge)	Full Bridge Replacement	$308.00	75	Rating = 8
Repair (After Bridge Replace)	Patch Spalls / Seal Cracks	$6.60	20	+ 1
Repair (After Rehab)	Patch Spalls / Seal Cracks	$6.60	10	+ 1

SUBSTRUCTURE - STRUCTURAL

ITEM	DESCRIPTION	UNIT COST (Per SF)	LIFE (YRS)	RATING BENEFIT
Replace (Substr)	Full SubStr Replacement	$154.00	75	Rating = 8
Rehab (Substr)	Replace Structural Component	$77.00	50	+ 2
Repair (Substr)	Patch Spalls / Seal Cracks	$11.00	See Deterioration Slope	+ 1

SUBSTRUCTURE - SCOUR

ITEM	DESCRIPTION	UNIT COST (Per SF)	LIFE (YRS)	RATING BENEFIT
Rehab (Substr - Scour)	Add scour protection slabs	$77.00	50	+ 2
Repair (Substr - Scour)	Patch Spalls / Seal Cracks	$11.00	See Deterioration Slope	+ 1
Replace (Bridge)	Full Bridge Replacement	$308.00	75	Rating = 8
Repair (After Bridge Replace)	Patch Spalls / Seal Cracks	$6.60	20	+ 1
Repair (After Rehab)	Patch Spalls / Seal Cracks	$6.60	10	+ 1

Notes:

1. Individual replacements assume 50% of total bridge replacement costs

2. Individual rehabs (in cells that are not highlighted) assume 25% of total bridge replacement costs

3. When superstructure replacement is selected, either deck replacement or deck rehab should be selected as well.

MCGUIREVILLE TI (#652) / I-17 / MP 293.26

Option 1 - Replace Bridge Now

Bridge Deck Area =	8995 SF
Widen Deck Area =	12079 SF
Year Built =	1961
Exp Service Life =	75 YR

Notes:

1. Red fill in "Year" column means current bridge is nearing the end of its expected service life.
2. When superstructure replacement is selected, deck replacement should be selected as well.
3. Deck Rehab does not account for any deck widening during replacement.
4. Widened deck area applies to bridge replacement only.
5. Repair deck (after bridge replace) should provide a deck deterioration of 1 point every 20 years.

Item	Deterioration Line Equation			Year Drop
	Slope =	Days	Years	
Substr	y =	-0.000137x	-0.050x	20.00
Superstr	y =	-0.000996x	-0.364x	2.75
Deck	y =	-0.000268x	-0.098x	10.22

		Substructure						*Superstructure*						*Deck*						*Summary*			
	Year	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Minimum Rating	Total Cost Per Year	Present Value at 3%	Present Value at 7%
0	2015	7						4						7									
1	2016	7						4						7									
2	2017	7	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.					4	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.					7	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.								
3	2018	7						4						7									
4	2019	7						4						7									
5	2020	7						4						7									
6	2021	8	Replace (Bridge)	$308.00	$3,720,332.00	75	Rating = 8	8	Replace (Bridge)			75	Rating = 8	8	Replace (Bridge)			75	Rating = 8	8	$3,720,332.00	$3,115,719.48	$2,479,014.30
7	2022	8						8						8						8			
8	2023	8						8						8						8			
9	2024	8						8						8						8			
10	2025	8						8						8						8			
11	2026	8						8						8						8			
12	2027	8						8						8						8			
13	2028	8						8						8						8			
14	2029	8						8						8						8			
15	2030	8						8						8						8			
16	2031	7						7						7						7			
17	2032	7						7						7						7			
18	2033	7						7						7						7			
19	2034	7						7						7						7			
20	2035	7						7						7						7			
21	2036	7						7						7						7			
22	2037	7						7						7						7			
23	2038	7						7						7						7			
24	2039	7						7						7						7			
25	2040	6						6						6						6			
26	2041	7	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+ 1	7	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+ 1	7	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+ 0	7	$239,164.20	$110,899.18	$41,183.00
27	2042	7						7						7						7			
28	2043	7						7						7						7			
29	2044	7						7						7						7			
30	2045	7						7						7						7			
31	2046	7						7						7						7			
32	2047	7						7						7						7			
33	2048	7						7						7						7			
34	2049	7						7						7						7			
35	2050	7						7						7						7			
36	2051	6						6						6						6			
37	2052	6						6						6						6			
38	2053	6						6						6						6			
39	2054	6						6						6						6			
40	2055	6						6						6						6			
41	2056	6						6						6						6			
42	2057	6						6						6						6			
43	2058	6						6						6						6			
44	2059	6						6						6						6			
45	2060	5						5						5						5			
46	2061	6	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+ 1	6	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+ 1	6	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+ 0	6	$239,164.20	$61,402.19	$10,642.47
47	2062	6						6						6						6			
48	2063	6						6						6						6			
49	2064	6						6						6						6			
50	2065	6						6						6						6			
51	2066	6						6						6						6			
52	2067	6						6						6						6			
53	2068	6						6						6						6			
54	2069	6						6						6						6			
55	2070	5						5						5						5			
56	2071	5						5						5						5			
57	2072	5						5						5						5			
58	2073	5						5						5						5			
59	2074	5						5						5						5			
60	2075	5						5						5						5			
61	2076	5						5						5						5			
62	2077	5						5						5						5			
63	2078	5						5						5						5			
64	2079	5						5						5						5			
65	2080	5						5						5						5			
																				Total Cost =	**$4,198,660.40**	**$3,288,020.84**	**$2,530,839.76**

Average Rating =	6.45
End Rating =	5

Comments:

MCGUIREVILLE TI (#652) / I-17 / MP 293.26

Option 2 - Perform Bridge Rehabilitiation Then Replace

Bridge Deck Area =	8995 SF
Widen Deck Area =	12079 SF
Year Built =	1961
Exp Service Life =	75 YR

Notes:

1. Red fill in "Year" column means current bridge is nearing the end of its expected service life.
2. When superstructure replacement is selected, deck replacement should be selected as well.
3. Deck Rehab does not account for any deck widening during replacement.
4. Widened deck area applies to bridge replacement only.
5. Repair deck (after bridge replace) should provide a deck deterioration of 1 point every 20 years. Repair (Deck) should maintain deck rating for life of repair, if the rating would otherwise drop a point (i.e., if the rating would drop from a "5" to a "4", Repair Deck would maintain a "5" at that year.)
6. For other repair items, the "+" value rating should be applied to improve the bridge rating's value for that year.

Item	Deterioration Line Equation			Year Drop
	Slope =	Days	Years	
Substr	y =	-0.000137x	-0.050x	20.00
Superstr	y =	-0.000996x	-0.364x	2.75
Deck	y =	-0.000268x	-0.098x	10.22

		Substructure						*Superstructure*						*Deck*						*Summary*			
	Year	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Minimum Rating	Total Cost Per Year	Present Value at 3%	Present Value at 7%
0	2015	7						4						7									
1	2016	7						4						7									
2	2017	7	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.					4	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.					7	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.									
3	2018	7						4						7									
4	2019	7						4						7									
5	2020	7						4						7									
6	2021	7	Repair (Substr)	$11.00	$98,945.00	20	+ 1	8	Replace (Supr - Stl)	$154.00	$1,385,230.00	50	Rating = 8	8	Replace (Deck)	$154.00	$1,385,230.00	25	Rating = 8	7	$2,869,405.00	$2,403,081.51	$1,912,005.71
7	2022	7						8						8						7			
8	2023	7						8						8						7			
9	2024	6						8						8						6			
10	2025	6						8						8						6			
11	2026	6						8						8						6			
12	2027	6						8						8						6			
13	2028	6						8						8						6			
14	2029	6						8						8						6			
15	2030	6						8						8						6			
16	2031	6						7						7						6			
17	2032	6						7						7						6			
18	2033	6						7						7						6			
19	2034	5						7						7						5			
20	2035	5						7						7						5			
21	2036	5						7						7						5			
22	2037	5						7						7						5			
23	2038	5						7						7						5			
24	2039	5						7						7						5			
25	2040	5						7						7						5			
26	2041	5						6						6						5			
27	2042	5						6						6						5			
28	2043	5						6						6						5			
29	2044	4						6						6						4			
30	2045	8	Replace (Bridge)	$308.00	$3,720,332.00	75	Rating = 8	8	Replace (Bridge)			75	Rating = 8	8	Replace (Bridge)			75	Rating = 8	8	$3,720,332.00	$1,532,727.53	$488,729.29
31	2046	8						8						8						8			
32	2047	8						8						8						8			
33	2048	8						8						8						8			
34	2049	8						8						8						8			
35	2050	8						8						8						8			
36	2051	8						8						8						8			
37	2052	8						8						8						8			
38	2053	8						8						8						8			
39	2054	8						8						8						8			
40	2055	7						7						7						7			
41	2056	7						7						7						7			
42	2057	7						7						7						7			
43	2058	7						7						7						7			
44	2059	7						7						7						7			
45	2060	7						7						7						7			
46	2061	7						7						7						7			
47	2062	7						7						7						7			
48	2063	7						7						7						7			
49	2064	6						6						6						6			
50	2065	7	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+ 1	7	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+ 1	7	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+ 0	7	$239,164.20	$54,555.05	$8,119.09
51	2066	7						7						7						7			
52	2067	7						7						7						7			
53	2068	7						7						7						7			
54	2069	7						7						7						7			
55	2070	7						7						7						7			
56	2071	7						7						7						7			
57	2072	7						7						7						7			
58	2073	7						7						7						7			
59	2074	7						7						7						7			
60	2075	6						6						6						6			
61	2076	6						6						6						6			
62	2077	6						6						6						6			
63	2078	6						6						6						6			
64	2079	6						6						6						6			
65	2080	6						6						6						6			
																				Total Cost =	**$6,828,901.20**	**$3,990,364.09**	**$2,408,854.09**

Average Rating =	6.50
End Rating =	6

Comments:

1. Given history of girder impacts/repairs, this option assumes that bearing pedestals would be provided along with a replaced superstructure to provide ample clearance. Deck replacement included as well. Superstructure replacement may only require jacking/new pedestals.

MCGUIREVILLE TI (#652) / I-17 / MP 293.26

Option 3 - Perform Minimum Repairs Then Replace

Bridge Deck Area =	8995 SF
Widen Deck Area =	12079 SF
Year Built =	1961
Exp Service Life =	75 YR

Notes:

1. Red fill in "Year" column means current bridge is nearing the end of its expected service life.
2. When superstructure replacement is selected, deck replacement should be selected as well.
3. Deck Rehab does not account for any deck widening during replacement.
4. Widened deck area applies to bridge replacement only.
5. Repair deck (after bridge replace) should provide a deck deterioration of 1 point every 20 years. Repair (Deck) should maintain deck rating for life of repair, if the rating would otherwise drop a point (i.e., if the rating would drop from a "5" to a "4", Repair Deck would maintain a "5" at that year.
6. For other repair items, the "+" value rating should be applied to improve the bridge rating's value for that year.

Item	Deterioration Line Equation Slope =	Days	Years	Year Drop
Substr	y =	-0.000137x	-0.050x	20.00
Superstr	y =	-0.000996x	-0.364x	2.75
Deck	y =	-0.000268x	-0.098x	10.22

		Substructure						*Superstructure*						*Deck*						*Summary*			
	Year	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Minimum Rating	Total Cost Per Year	Present Value at 3%	Present Value at 7%
0	2015	7						4						7									
1	2016	7						4						7									
2	2017	7	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.					4	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.					7	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.								
3	2018	7						4						7									
4	2019	7						4						7									
5	2020	7						4						7									
6	2021	7						5	Repair (Supr - Stl)	$11.00	$98,945.00	3	+1	7						5	$98,945.00	$82,864.88	$65,931.23
7	2022	7						5						7						5			
8	2023	7						4						7						4			
9	2024	6						5	Repair (Supr - Stl)	$11.00	$98,945.00	3	+1	7						5	$98,945.00	$75,833.10	$53,819.52
10	2025	6						5						6						5			
11	2026	6						4						6						4			
12	2027	6						5	Repair (Supr - Stl)	$11.00	$98,945.00	3	+1	6						5	$98,945.00	$69,398.03	$43,932.76
13	2028	6						5						6						5			
14	2029	6						4						6						4			
15	2030	6						5	Repair (Supr - Stl)	$11.00	$98,945.00	3	+1	6						5	$98,945.00	$63,509.03	$35,862.22
16	2031	6						5						6						5			
17	2032	6						4						6						4			
18	2033	6						5	Repair (Supr - Stl)	$11.00	$98,945.00	3	+1	6						5	$98,945.00	$58,119.76	$29,274.26
19	2034	6						5						6						5			
20	2035	6						4						5						4			
21	2036	8	Replace (Bridge)	$308.00	$3,720,332.00	75	Rating = 8	8	Replace (Bridge)			75	Rating = 8	8	Replace (Bridge)			75	Rating = 8	8	$3,720,332.00	$1,999,861.77	$898,508.87
22	2037	8						8						8						8			
23	2038	8						8						8						8			
24	2039	8						8						8						8			
25	2040	8						8						8						8			
26	2041	8						8						8						8			
27	2042	8						8						8						8			
28	2043	8						8						8						8			
29	2044	8						8						8						8			
30	2045	8						8						8						8			
31	2046	7						7						7						7			
32	2047	7						7						7						7			
33	2048	7						7						7						7			
34	2049	7						7						7						7			
35	2050	7						7						7						7			
36	2051	7						7						7						7			
37	2052	7						7						7						7			
38	2053	7						7						7						7			
39	2054	7						7						7						7			
40	2055	6						6						6						6			
41	2056	7	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+1	7	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+1	7	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+0	7	$239,164.20	$71,181.96	$14,926.61
42	2057	7						7						7						7			
43	2058	7						7						7						7			
44	2059	7						7						7						7			
45	2060	7						7						7						7			
46	2061	7						7						7						7			
47	2062	7						7						7						7			
48	2063	7						7						7						7			
49	2064	7						7						7						7			
50	2065	7						7						7						7			
51	2066	6						6						6						6			
52	2067	6						6						6						6			
53	2068	6						6						6						6			
54	2069	6						6						6						6			
55	2070	6						6						6						6			
56	2071	6						6						6						6			
57	2072	6						6						6						6			
58	2073	6						6						6						6			
59	2074	6						6						6						6			
60	2075	5						5						5						5			
61	2076	6	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+1	6	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+1	6	Repair (After Bridge Replace)	$6.60	$79,721.40	20	+0	6	$239,164.20	$39,411.73	$3,857.32
62	2077	6						6						6						6			
63	2078	6						6						6						6			
64	2079	6						6						6						6			
65	2080	6						6						6						6			
																				Total Cost =	**$4,693,385.40**	**$2,460,180.27**	**$1,146,112.79**

Average Rating =	6.30
End Rating =	6

Comments:

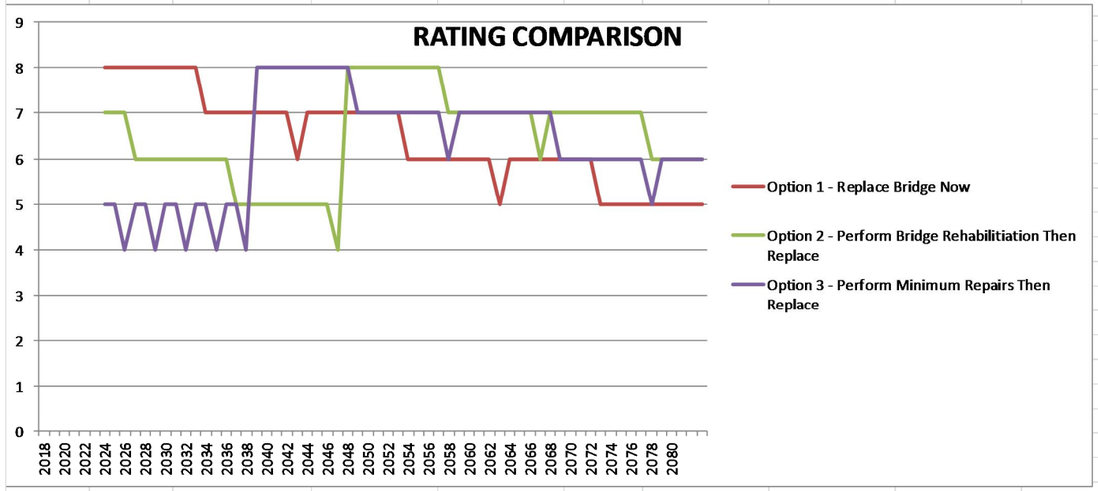
1. Repairs carried out in 2014...not reflected in current inspection. Evaluation assumes, however, that girder impacts/repairs are likely to continue with posted vertical clearance of 14'-8".

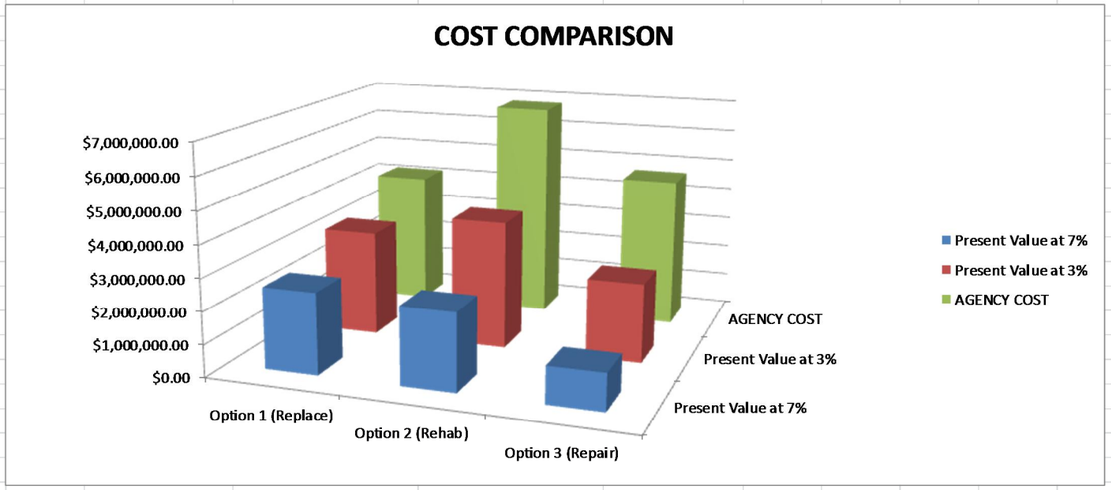
MCGUIREVILLE TI (#652) / I-17 / MP 293.26

COST COMPARISON Present Value Dollars			
OPTION	AGENCY COST	3%	7%
Option 1 (Replace)	$ 4,198,660.40	$3,288,020.84	$2,530,839.76
Option 2 (Rehab)	$ 6,828,901.20	$3,990,364.09	$2,408,854.09
Option 3 (Repair)	$ 4,693,385.40	$2,460,180.27	$1,146,112.79

Comparison to Replacement			
Option	Agency Cost	3%	7%
2 (Rehab)	61.48%	82.40%	105.06%
3 (Repair)	89.46%	133.65%	220.82%

Bridge Ratings Per Option		
OPTION	AVG RATING	END RATING
Option 1 (Replace)	6.45	5
Option 2 (Rehab)	6.50	6
Option 3 (Repair)	6.30	6





	Present Value at 7%	Present Value at 3%	AGENCY COST
Option 1 (Replace)	$2,530,839.76	$3,288,020.84	$ 4,198,660.40
Option 2 (Rehab)	$2,408,854.09	$3,990,364.09	$ 6,828,901.20
Option 3 (Repair)	$1,146,112.79	$2,460,180.27	$ 4,693,385.40

AIRPORT ROAD TI (#632) / I-17 / MP 337.39

Bridge Information	
Bridge Deck Area (A225)	7010 SF
Year Built (N27)	1959
Exp Service Life	75 YR
Total Bridge Length (N49)	209 LF
Number of Spans (N45+N46)	5
Skew Angle (N34)	4 DEG
Average Elevation	7008 FT
Max Pier Height	16 FT
* Amount of Widening for Bridge	12 FT
Revised Deck Area (Bridge Replace)	9518 FT
**Scour Critical Rating (N113)	N/A

Deterioration Slope

Item	Deterioration Line Equation			Year Drop
	Slope =	Days	Years	
Substr	y =	-0.000913x	-0.333x	3.00
Superstr	y =	-0.000769x	-0.281x	3.56
Deck	y =	-0.000687x	-0.251x	3.99

*Input 0 if no widening. Input should include widening on both sides of bridge if applicable.

**If scour critical rating is 3 or lower, Option 2 should consider the implementation of scour countermeasures.

Notes:

1. Widening is intended only to correct lane and/or shoulder width deficiencies. It is not intended for adding traffic capacity (i.e. adding general purpose lanes).

Cost Multipliers		
Elevation > 4000ft	7008	1.25
Pier Height > 30ft	16	1.00
Length to # span ratio	41.80	1.25
Skew > 30degrees	4.00	1.00

L to # Span Multiplier

L/ # Span Ratio	Multiplier
=>100	1.00
=>60	1.10
<60	1.25

Skew Multiplier

Skew	Multiplier
<30	1.00
=>30	1.10

Adjusted Bridge Replace Cost	
Base Bridge Replacement Cost (Per SF)	$280.00
Bridge Replacement Cost w/ Multipliers (Per SF)	$437.50

Elevation Multiplier

Elev	Multiplier
<4000	1.00
=>4000	1.25

Pier H Multiplier

Pier H	Multiplier
<30	1.00
=>30	1.10

User input cell

Only manipulate cell value after consulting with team

Bridge History (Inspections/As-builts)

Description	Category	Year
Original bridge was built in 1959 (18-2(9)138RD).		
Bridge was rehabilitated in 2011 (BR-017-B(213)A). Bridge rehabilitation consisted of:		
a. Methacrylate deck sealant/new concrete overlay (with reinforcement).	Rehab (Deck Concrete Overlay)	2011
b. Abutment corner repairs (dowels/fresh concrete) / pier cap repairs (shotcrete).	Repair (Substr)	2011
c. Precast box beam repairs.	Repair (Supr - Conc)	2011
Latest deck inspection shows that deck top has heavy density hairline to narrow sized longitudinal, transverse, and map cracks. Also, barriers		
have scaling/spalls. Box beams have impact scrapes, spalls, and cut strands. 2 interior box beams have large spalls.		
All pier caps have wide cracks, delaminations, and spalls with scaling at end caps. Columns have scaling, spalls, and rust coloration.		

Replace / Rehab / Repair Information

BRIDGE DECK

ITEM	DESCRIPTION	UNIT COST (Per SF)	LIFE (YRS)	RATING BENEFIT
Replace (Deck)	Full Deck Replacement	$218.75	25	Rating = 8
Rehab (Deck Concrete Overlay)	Overlay (Concrete)	$22.00	15	+ 2
Rehab (Deck Epoxy Overlay)	Overlay (Epoxy)	$11.00	10	+ 1
Repair (Deck)	Patch Spalls / Seal Cracks	$6.60	See Deterioration Slope	+ 0
Replace (Bridge)	Full Bridge Replacement	$437.50	75	Rating = 8
Repair (After Bridge Replace)	Patch Spalls / Seal Cracks	$6.60	20	+ 0
Repair (After Rehab)	Patch Spalls / Seal Cracks	$6.60	10	+ 0

SUPERSTRUCTURE - STEEL

ITEM	DESCRIPTION	UNIT COST (Per SF)	LIFE (YRS)	RATING BENEFIT
Replace (Supr - Stl)	Full SuperStr Replacement	$218.75	50	Rating = 8
Rehab (Supr - Stl)	Weld New Structural Components	$109.38	15	+ 2
Repair (Supr - Stl)	Weld Repair / Crack Relief	$11.00	See Deterioration Slope	+ 1

SUPERSTRUCTURE - CONCRETE

ITEM	DESCRIPTION	UNIT COST (Per SF)	LIFE (YRS)	RATING BENEFIT
Replace (Supr - Conc)	Full SuperStr Replacement	$218.75	50	Rating = 8
Rehab (Supr - Conc)	Replace Structural Component	$109.38	15	+ 2
Repair (Supr - Conc)	Patch Spalls / Seal Cracks	$11.00	See Deterioration Slope	+ 1
Replace (Bridge)	Full Bridge Replacement	$437.50	75	Rating = 8
Repair (After Bridge Replace)	Patch Spalls / Seal Cracks	$6.60	20	+ 1
Repair (After Rehab)	Patch Spalls / Seal Cracks	$6.60	10	+ 1

SUBSTRUCTURE - STRUCTURAL

ITEM	DESCRIPTION	UNIT COST (Per SF)	LIFE (YRS)	RATING BENEFIT
Replace (Substr)	Full SubStr Replacement	$218.75	75	Rating = 8
Rehab (Substr)	Replace Structural Component	$109.38	50	+ 2
Repair (Substr)	Patch Spalls / Seal Cracks	$11.00	See Deterioration Slope	+ 1

SUBSTRUCTURE - SCOUR

ITEM	DESCRIPTION	UNIT COST (Per SF)	LIFE (YRS)	RATING BENEFIT
Rehab (Substr - Scour)	Add scour protection slabs	$109.38	50	+ 2
Repair (Substr - Scour)	Patch Spalls / Seal Cracks	$11.00	See Deterioration Slope	+ 1
Replace (Bridge)	Full Bridge Replacement	$437.50	75	Rating = 8
Repair (After Bridge Replace)	Patch Spalls / Seal Cracks	$6.60	20	+ 1
Repair (After Rehab)	Patch Spalls / Seal Cracks	$6.60	10	+ 1

Notes:

1. Individual replacements assume 50% of total bridge replacement costs

2. Individual rehabs (in cells that are not highlighted) assume 25% of total bridge replacement costs

3. When superstructure replacement is selected, either deck replacement or deck rehab should be selected as well.

AIRPORT ROAD TI (#632) / I-17 / MP 337.39

Option 1 - Replace Bridge Now

Bridge Deck Area =	7010 SF
Widen Deck Area =	9518 SF
Year Built =	1959
Exp Service Life =	75 YR

Notes:

1. Red fill in "Year" column means current bridge is nearing the end of its expected service life.
2. When superstructure replacement is selected, deck replacement should be selected as well.
3. Deck Rehab does not account for any deck widening during replacement.
4. Widened deck area applies to bridge replacement only.
5. Repair deck (after bridge replace) should provide a deck deterioration of 1 point every 20 years.

Item	Deterioration Line Equation Slope =	Days	Years	Year Drop
Substr	y =	-0.000913x	-0.333x	3.00
Superstr	y =	-0.000769x	-0.281x	3.56
Deck	y =	-0.000687x	-0.251x	3.99

		Substructure						*Superstructure*						*Deck*						*Summary*			
	Year	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Minimum Rating	Total Cost Per Year	Present Value at 3%	Present Value at 7%
0	2015	5						5						6									
1	2016	5						5						6									
2	2017	5	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.					5	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.					6	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.								
3	2018	4						4						6									
4	2019	4						4						5									
5	2020	4						4						5									
6	2021	8	Replace (Bridge)	$437.50	$4,164,125.00	75	Rating = 8	8	Replace (Bridge)			75	Rating = 8	8	Replace (Bridge)			75	Rating = 8	8	$4,164,125.00	$3,487,389.13	$2,774,732.31
7	2022	8						8						8						8			
8	2023	8						8						8						8			
9	2024	8						8						8						8			
10	2025	8						8						8						8			
11	2026	8						8						8						8			
12	2027	8						8						8						8			
13	2028	8						8						8						8			
14	2029	8						8						8						8			
15	2030	8						8						8						8			
16	2031	7						7						7						7			
17	2032	7						7						7						7			
18	2033	7						7						7						7			
19	2034	7						7						7						7			
20	2035	7						7						7						7			
21	2036	7						7						7						7			
22	2037	7						7						7						7			
23	2038	7						7						7						7			
24	2039	7						7						7						7			
25	2040	6						6						6						6			
26	2041	7	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+ 1	7	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+ 1	7	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+ 0	7	$188,456.40	$87,386.24	$32,451.34
27	2042	7						7						7						7			
28	2043	7						7						7						7			
29	2044	7						7						7						7			
30	2045	7						7						7						7			
31	2046	7						7						7						7			
32	2047	7						7						7						7			
33	2048	7						7						7						7			
34	2049	7						7						7						7			
35	2050	7						7						7						7			
36	2051	6						6						6						6			
37	2052	6						6						6						6			
38	2053	6						6						6						6			
39	2054	6						6						6						6			
40	2055	6						6						6						6			
41	2056	6						6						6						6			
42	2057	6						6						6						6			
43	2058	6						6						6						6			
44	2059	6						6						6						6			
45	2060	5						5						5						5			
46	2061	6	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+ 1	6	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+ 1	6	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+ 0	6	$188,456.40	$48,383.64	$8,386.04
47	2062	6						6						6						6			
48	2063	6						6						6						6			
49	2064	6						6						6						6			
50	2065	6						6						6						6			
51	2066	6						6						6						6			
52	2067	6						6						6						6			
53	2068	6						6						6						6			
54	2069	6						6						6						6			
55	2070	5						5						5						5			
56	2071	5						5						5						5			
57	2072	5						5						5						5			
58	2073	5						5						5						5			
59	2074	5						5						5						5			
60	2075	5						5						5						5			
61	2076	5						5						5						5			
62	2077	5						5						5						5			
63	2078	5						5						5						5			
64	2079	5						5						5						5			
65	2080	5						5						5						5			
																				Total Cost =	**$4,541,037.80**	**$3,623,159.01**	**$2,815,569.70**

Average Rating =	6.45
End Rating =	5

Comments:

AIRPORT ROAD TI (#632) / I-17 / MP 337.39

Option 2 - Perform Bridge Rehabilitiation Then Replace

Bridge Deck Area =	7010 SF
Widen Deck Area =	9518 SF
Year Built =	1959
Exp Service Life =	75 YR

Notes:

1. Red fill in "Year" column means current bridge is nearing the end of its expected service life.
2. When superstructure replacement is selected, deck replacement should be selected as well.
3. Deck Rehab does not account for any deck widening during replacement.
4. Widened deck area applies to bridge replacement only.
5. Repair deck (after bridge replace) should provide a deck deterioration of 1 point every 20 years. Repair (Deck) should maintain deck rating for life of repair, if the rating would otherwise drop a point (i.e., if the rating would drop from a "5" to a "4", Repair Deck would maintain a "5" at that year.)
6. For other repair items, the "+" value rating should be applied to improve the bridge rating's value for that year.

Item	Deterioration Line Equation Slope =	Days	Years	Year Drop
Substr	y =	-0.000913x	-0.333x	3.00
Superstr	y =	-0.000769x	-0.281x	3.56
Deck	y =	-0.000687x	-0.251x	3.99

		Substructure						*Superstructure*						*Deck*						*Summary*			
	Year	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Minimum Rating	Total Cost Per Year	Present Value at 3%	Present Value at 7%
0	2015	5	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.					5	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.					6	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.								
1	2016	5						5						6									
2	2017	5						5						6									
3	2018	4						4						6									
4	2019	4						4						5									
5	2020	4						4						5									
6	2021	5	Repair (Substr)	$11.00	$77,110.00	3	+1	5	Repair (Supr - Conc)	$11.00	$77,110.00	4	+1	5						5	$154,220.00	$129,156.82	$102,763.30
7	2022	5						5						5						5			
8	2023	5						5						4						4			
9	2024	4						4						6	Rehab (Deck Concrete Overlay)	$22.00	$154,220.00	15	+2	4	$154,220.00	$118,196.79	$83,885.46
10	2025	5	Repair (Substr)	$11.00	$77,110.00	3	+1	5	Repair (Supr - Conc)	$11.00	$77,110.00	4	+1	6						5	$154,220.00	$114,754.16	$78,397.63
11	2026	5						5						6						5			
12	2027	5						5						6						5			
13	2028	4						4						6						4			
14	2029	5	Repair (Substr)	$11.00	$77,110.00	3	+1	5	Repair (Supr - Conc)	$11.00	$77,110.00	4	+1	6						5	$154,220.00	$101,957.59	$59,809.17
15	2030	5						5						6						5			
16	2031	5						5						5						5			
17	2032	4						4						5						4			
18	2033	5	Repair (Substr)	$11.00	$77,110.00	3	+1	5	Repair (Supr - Conc)	$11.00	$77,110.00	4	+1	5						5	$154,220.00	$90,588.00	$45,628.13
19	2034	8	Replace (Bridge)	$437.50	$4,164,125.00	75	Rating = 8	8	Replace (Bridge)			75	Rating = 8	8	Replace (Bridge)			75	Rating = 8	8	$4,164,125.00	$2,374,742.30	$1,151,415.26
20	2035	8						8						8						8			
21	2036	8						8						8						8			
22	2037	8						8						8						8			
23	2038	8						8						8						8			
24	2039	8						8						8						8			
25	2040	8						8						8						8			
26	2041	8						8						8						8			
27	2042	8						8						8						8			
28	2043	8						8						8						8			
29	2044	7						7						7						7			
30	2045	7						7						7						7			
31	2046	7						7						7						7			
32	2047	7						7						7						7			
33	2048	7						7						7						7			
34	2049	7						7						7						7			
35	2050	7						7						7						7			
36	2051	7						7						7						7			
37	2052	7						7						7						7			
38	2053	6						6						6						6			
39	2054	7	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+1	7	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+1	7	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+0	7	$188,456.40	$59,505.78	$13,466.15
40	2055	7						7						7						7			
41	2056	7						7						7						7			
42	2057	7						7						7						7			
43	2058	7						7						7						7			
44	2059	7						7						7						7			
45	2060	7						7						7						7			
46	2061	7						7						7						7			
47	2062	7						7						7						7			
48	2063	7						7						7						7			
49	2064	6						6						6						6			
50	2065	6						6						6						6			
51	2066	6						6						6						6			
52	2067	6						6						6						6			
53	2068	6						6						6						6			
54	2069	6						6						6						6			
55	2070	6						6						6						6			
56	2071	6						6						6						6			
57	2072	6						6						6						6			
58	2073	5						5						5						5			
59	2074	6	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+1	6	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+1	6	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+0	6	$188,456.40	$32,946.91	$3,479.91
60	2075	6						6						6						6			
61	2076	6						6						6						6			
62	2077	6						6						6						6			
63	2078	6						6						6						6			
64	2079	6						6						6						6			
65	2080	6						6						6						6			
																				Total Cost =	**$5,312,137.80**	**$3,021,848.34**	**$1,538,845.02**

Average Rating =	6.35
End Rating =	6

Comments:

AIRPORT ROAD TI (#632) / I-17 / MP 337.39

Option 3 - Perform Minimum Repairs Then Replace

Bridge Deck Area =	7010 SF
Widen Deck Area =	9518 SF
Year Built =	1959
Exp Service Life =	75 YR

Notes:

1. Red fill in "Year" column means current bridge is nearing the end of its expected service life.
2. When superstructure replacement is selected, deck replacement should be selected as well.
3. Deck Rehab does not account for any deck widening during replacement.
4. Widened deck area applies to bridge replacement only.
5. Repair deck (after bridge replace) should provide a deck deterioration of 1 point every 20 years. Repair (Deck) should maintain deck rating for life of repair, if the rating would otherwise drop a point (i.e., if the rating would drop from a "5" to a "4", Repair Deck would maintain a "5" at that year.
6. For other repair items, the "+" value rating should be applied to improve the bridge rating's value for that year.

Item	Deterioration Line Equation			Year Drop
	Slope =	Days	Years	
Substr	y =	-0.000913x	-0.333x	3.00
Superstr	y =	-0.000769x	-0.281x	3.56
Deck	y =	-0.000687x	-0.251x	3.99

		Substructure						*Superstructure*						*Deck*						*Summary*			
	Year	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Rating	Item	Cost (Per SF)	Cost (Total)	Service Life	Rating Increase	Minimum Rating	Total Cost Per Year	Present Value at 3%	Present Value at 7%
0	2015	5						5						6									
1	2016	5						5						6									
2	2017	5	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.					5	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.					6	No Rehab/Repair Work Can Be Done. Not Yet In 5-Year Program.								
3	2018	4						4						6									
4	2019	4						4						5									
5	2020	4						4						5									
6	2021	5	Repair (Substr)	$11.00	$77,110.00	3	+1	5	Repair (Supr - Conc)	$11.00	$77,110.00	4	+1	5						5	$154,220.00	$129,156.82	$102,763.30
7	2022	5						5						5						5			
8	2023	4						5						5	Repair (Deck)	$6.60	$46,266.00	4	+0	4	$46,266.00	$36,522.81	$26,927.23
9	2024	5	Repair (Substr)	$11.00	$77,110.00	3	+1	4						5						4	$77,110.00	$59,098.39	$41,942.73
10	2025	5						5	Repair (Supr - Conc)	$11.00	$77,110.00	4	+1	5						5	$77,110.00	$57,377.08	$39,198.81
11	2026	4						5						5						4			
12	2027	5	Repair (Substr)	$11.00	$77,110.00	3	+1	5						5	Repair (Deck)	$6.60	$46,266.00	4	+0	5	$123,376.00	$86,533.44	$54,780.42
13	2028	5						4						5						4			
14	2029	4						5	Repair (Supr - Conc)	$11.00	$77,110.00	4	+1	5						4	$77,110.00	$50,978.79	$29,904.59
15	2030	5	Repair (Substr)	$11.00	$77,110.00	3	+1	5						5						5	$77,110.00	$49,493.97	$27,948.21
16	2031	5						5						5	Repair (Deck)	$6.60	$46,266.00	4	+0	5	$46,266.00	$28,831.44	$15,671.89
17	2032	4						4						5						4			
18	2033	5	Repair (Substr)	$11.00	$77,110.00	3	+1	5	Repair (Supr - Conc)	$11.00	$77,110.00	4	+1	5						5	$154,220.00	$90,588.00	$45,628.13
19	2034	8	Replace (Bridge)	$437.50	$4,164,125.00	75	Rating = 8	8	Replace (Bridge)			75	Rating = 8	8	Replace (Bridge)			75	Rating = 8	8	$4,164,125.00	$2,374,742.30	$1,151,415.26
20	2035	8						8						8						8			
21	2036	8						8						8						8			
22	2037	8						8						8						8			
23	2038	8						8						8						8			
24	2039	8						8						8						8			
25	2040	8						8						8						8			
26	2041	8						8						8						8			
27	2042	8						8						8						8			
28	2043	8						8						8						8			
29	2044	7						7						7						7			
30	2045	7						7						7						7			
31	2046	7						7						7						7			
32	2047	7						7						7						7			
33	2048	7						7						7						7			
34	2049	7						7						7						7			
35	2050	7						7						7						7			
36	2051	7						7						7						7			
37	2052	7						7						7						7			
38	2053	6						6						6						6			
39	2054	7	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+1	7	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+1	7	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+0	7	$188,456.40	$59,505.78	$13,466.15
40	2055	7						7						7						7			
41	2056	7						7						7						7			
42	2057	7						7						7						7			
43	2058	7						7						7						7			
44	2059	7						7						7						7			
45	2060	7						7						7						7			
46	2061	7						7						7						7			
47	2062	7						7						7						7			
48	2063	7						7						7						7			
49	2064	6						6						6						6			
50	2065	6						6						6						6			
51	2066	6						6						6						6			
52	2067	6						6						6						6			
53	2068	6						6						6						6			
54	2069	6						6						6						6			
55	2070	6						6						6						6			
56	2071	6						6						6						6			
57	2072	6						6						6						6			
58	2073	5						5						5						5			
59	2074	6	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+1	6	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+1	6	Repair (After Bridge Replace)	$6.60	$62,818.80	20	+0	6	$188,456.40	$32,946.91	$3,479.91
60	2075	6						6						6						6			
61	2076	6						6						6						6			
62	2077	6						6						6						6			
63	2078	6						6						6						6			
64	2079	6						6						6						6			
65	2080	6						6						6						6			
																				Total Cost =	**$5,373,825.80**	**$3,055,775.74**	**$1,553,126.65**

Average Rating =	6.32
End Rating =	6

Comments:

AIRPORT ROAD TI (#632) / I-17 / MP 337.39

COST COMPARISON Present Value Dollars

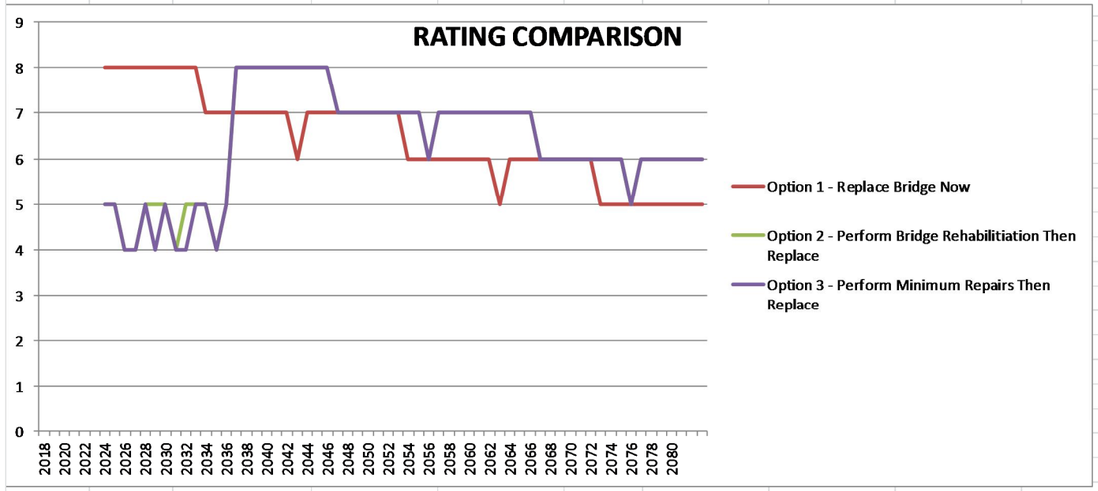
OPTION	AGENCY COST	3%	7%
Option 1 (Replace)	$ 4,541,037.80	$3,623,159.01	$2,815,569.70
Option 2 (Rehab)	$ 5,312,137.80	$3,021,848.34	$1,538,845.02
Option 3 (Repair)	$ 5,373,825.80	$3,055,775.74	$1,553,126.65

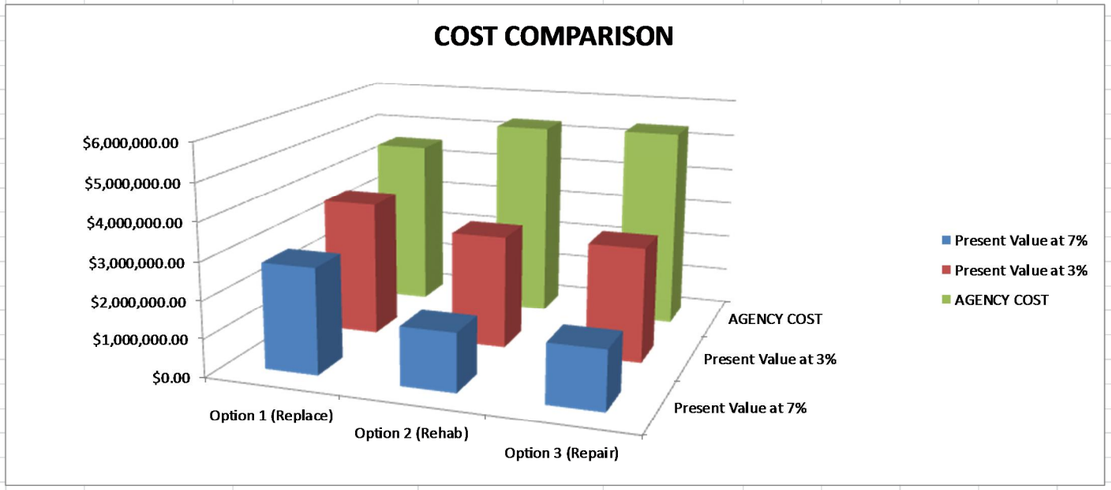
Comparison to Replacement

Option	Agency Cost	3%	7%
2 (Rehab)	85.48%	119.90%	182.97%
3 (Repair)	84.50%	118.57%	181.28%

Bridge Ratings Per Option

OPTION	AVG RATING	END RATING
Option 1 (Replace)	6.45	5
Option 2 (Rehab)	6.35	6
Option 3 (Repair)	6.32	6





	Present Value at 7%	Present Value at 3%	AGENCY COST
Option 1 (Replace)	$2,815,569.70	$3,623,159.01	$ 4,541,037.80
Option 2 (Rehab)	$1,538,845.02	$3,021,848.34	$ 5,312,137.80
Option 3 (Repair)	$1,553,126.65	$3,055,775.74	$ 5,373,825.80

Pavement Life-Cycle Cost Analysis Worksheet

Project Details

Project Description	Life-Cycle Cost Analysis for I-17 Corridor Profile Study: MP 339-340
Location #	I-17, Segment 17-12
Milepost Begin	339
Milepost End	340

Roadway Characteristics

Functional Classification	=	Interstate	
Surface Type	=	Concrete	‹‹Select from List
Traffic Directions	=	2	‹‹one-way or two-way traffic?
Number of Lanes [each direction]	=	2	
Width of Lanes (ft)	=	12	
Left shoulder width (ft)	=	4	
Right shoulder width (ft)	=	10	
Total Roadway Length (centerline miles)	=	1	
Current PSR Score	=	0	
Current Year	=	2015	
Roadway Width (ft) [each direction lanes & shoulders]	=	38	
Total Lane-Miles [Total traffic direction lanes & shoulders]	=	6.3	
Total Square Feet [Total traffic direction lanes & shoulders]	=	401,280	
Total Square Yards [Total traffic direction lanes & shoulders]	=	44,587	

LCCA Parameters

Analysis Period (Years)	=	40
Year of Net Present Value	=	2016
First Year of Improvements	=	2020
Discount Rate (%) - Low	=	3%
Discount Rate (%) - High	=	7%
Number of Design Alternatives	=	6
Trigger Level for Rehabilitation (PSR)	=	3.4

Design Alternatives (DA)

Pavement Material Cost ($)

Treatment Type	Pavement Thickness	Typical Service Life	Lane-miles	Square Feet	Square Yards
Concrete Reconstruction	8"-12"	15-25	$350,000	$5.5	$50
Asphalt Reconstruction	8"-12"	10-20	$280,000	$4.4	$40
Concrete Medium Rehab	1"-3"	11-15	$75,000	$1.2	$11
Concrete Light Rehab	<1"	6-10	$50,000	$0.8	$7
Asphalt Medium Rehab	3"-8"	8-12	$105,000	$1.7	$15
Asphalt Light Rehab	<3"	3-7	$70,000	$1.1	$10

Reconstruction: Other Materials Cost Factor

1.60

Rehab: Other Materials Cost Factor

1.20

Total Cost Factor (e.g., includes design, mobilization, traffic control, contingency, etc.)

2.44

Total Unit Cost ($) [includes material costs and indirect costs] — **Total Bi-Directional Cost ($)**

Treatment Type	Pavement Thickness	Typical Service Life	Lane-miles	Square Feet	Square Yards	Total Cost
Concrete Reconstruction	8"-12"	15-25	$1,366,400	$21.6	$194	$8,653,867
Asphalt Reconstruction	8"-12"	10-20	$1,093,120	$17.3	$155	$6,923,093
Concrete Medium Rehab	1"-3"	11-15	$219,600	$3.5	$31	$1,390,800
Concrete Light Rehab	<1"	6-10	$146,400	$2.3	$21	$927,200
Asphalt Medium Rehab	3"-8"	8-12	$307,440	$4.9	$44	$1,947,120
Asphalt Light Rehab	<3"	3-7	$204,960	$3.2	$29	$1,298,080

Pavement LCCA - I-17 MP 339-340

Deterioration rates

Asphalt	Interstate	Desert Zone	-0.053
Asphalt	Interstate	Other	-0.071
Concrete	Interstate	Desert Zone	-0.027
Concrete	Interstate	Other	-0.033

**For Asphalt - based on Figures 5.5 and 5.8*

**For Concrete - assumed half the asphalt deterioration*

**Based on PMS report 494, developing separte deterioration models for the different traffic and thickness classes are not waranted.*

Enter Name of Design Alternative

		Concrete Reconstruction	Agency Cost ($)	Net Present Value @ 3%	Net Present Value @ 7%
0	2015	None	$0	$0	$0
1	2016	None	$0	$0	$0
2	2017	None	$0	$0	$0
3	2018	None	$0	$0	$0
4	2019	None	$0	$0	$0
5	2020	Concrete Reconstruction	$8,653,867	$7,688,848	$6,601,993
6	2021	None	$0	$0	$0
7	2022	None	$0	$0	$0
8	2023	None	$0	$0	$0
9	2024	None	$0	$0	$0
10	2025	None	$0	$0	$0
11	2026	None	$0	$0	$0
12	2027	None	$0	$0	$0
13	2028	None	$0	$0	$0
14	2029	None	$0	$0	$0
15	2030	Concrete Light Rehab	$927,200	$612,988	$359,584
16	2031	None	$0	$0	$0
17	2032	None	$0	$0	$0
18	2033	None	$0	$0	$0
19	2034	None	$0	$0	$0
20	2035	None	$0	$0	$0
21	2036	None	$0	$0	$0
22	2037	None	$0	$0	$0
23	2038	None	$0	$0	$0
24	2039	None	$0	$0	$0
25	2040	Concrete Medium Rehab	$1,390,800	$684,181	$274,192
26	2041	None	$0	$0	$0
27	2042	None	$0	$0	$0
28	2043	None	$0	$0	$0
29	2044	None	$0	$0	$0
30	2045	None	$0	$0	$0
31	2046	None	$0	$0	$0
32	2047	None	$0	$0	$0
33	2048	None	$0	$0	$0
34	2049	None	$0	$0	$0
35	2050	Concrete Light Rehab	$927,200	$339,397	$92,923
36	2051	None	$0	$0	$0
37	2052	None	$0	$0	$0
38	2053	None	$0	$0	$0
39	2054	None	$0	$0	$0
40	2055	None	$0	$0	$0
41	2056	None	$0	$0	$0
42	2057	None	$0	$0	$0
43	2058	None	$0	$0	$0
44	2059	None	$0	$0	$0
45	2060	Concrete Medium Rehab	$1,390,800	$378,815	$70,856
46		None	$0	#VALUE!	#VALUE!
47		None	$0	#VALUE!	#VALUE!
48		None	$0	#VALUE!	#VALUE!
49		None	$0	#VALUE!	#VALUE!
50		None	$0	#VALUE!	#VALUE!
	2060	Pick Last Improvement to calculate Remaining Service Life ››	Remaining Service Life Cost ››	$1,390,800	$378,815	$70,856
		Enter Year of Last Improvement ››	2060			

	Net Present Value ($) @ 3%	Net Present Value ($) @ 7%
NET PRESENT VALUE	$9,325,415	$7,328,692
AGENCY COST	$11,899,067	

Pavement LCCA - I-17 MP 339-340

Deterioration rates

Asphalt	Interstate	Desert Zone	-0.053
Asphalt	Interstate	Other	-0.071
Concrete	Interstate	Desert Zone	-0.027
Concrete	Interstate	Other	-0.033

**For Asphalt - based on Figures 5.5 and 5.8*

**For Concrete - assumed half the asphalt deterioration*

**Based on PMS report 494, developing separte deterioration models for the different traffic and thickness classes are not waranted.*

Enter Name of Design Alternative

		Asphalt Reconstruction	Agency Cost ($)	Net Present Value @ 3%	Net Present Value @ 7%
0	2015	None	$0	$0	$0
1	2016	None	$0	$0	$0
2	2017	None	$0	$0	$0
3	2018	None	$0	$0	$0
4	2019	None	$0	$0	$0
5	2020	Asphalt Reconstruction	$6,923,093	$6,151,079	$5,281,595
6	2021	None	$0	$0	$0
7	2022	None	$0	$0	$0
8	2023	None	$0	$0	$0
9	2024	None	$0	$0	$0
10	2025	None	$0	$0	$0
11	2026	None	$0	$0	$0
12	2027	None	$0	$0	$0
13	2028	None	$0	$0	$0
14	2029	None	$0	$0	$0
15	2030	Asphalt Light Rehab	$1,298,080	$858,184	$503,418
16	2031	None	$0	$0	$0
17	2032	None	$0	$0	$0
18	2033	None	$0	$0	$0
19	2034	None	$0	$0	$0
20	2035	None	$0	$0	$0
21	2036	None	$0	$0	$0
22	2037	None	$0	$0	$0
23	2038	None	$0	$0	$0
24	2039	None	$0	$0	$0
25	2040	Asphalt Medium Rehab	$1,947,120	$957,854	$383,868
26	2041	None	$0	$0	$0
27	2042	None	$0	$0	$0
28	2043	None	$0	$0	$0
29	2044	None	$0	$0	$0
30	2045	None	$0	$0	$0
31	2046	None	$0	$0	$0
32	2047	None	$0	$0	$0
33	2048	None	$0	$0	$0
34	2049	None	$0	$0	$0
35	2050	Asphalt Light Rehab	$1,298,080	$475,156	$130,093
36	2051	None	$0	$0	$0
37	2052	None	$0	$0	$0
38	2053	None	$0	$0	$0
39	2054	None	$0	$0	$0
40	2055	None	$0	$0	$0
41	2056	None	$0	$0	$0
42	2057	None	$0	$0	$0
43	2058	None	$0	$0	$0
44	2059	None	$0	$0	$0
45	2060	Asphalt Reconstruction	$6,923,093	$1,885,655	$352,707
46		None	$0	#VALUE!	#VALUE!
47		None	$0	#VALUE!	#VALUE!
48		None	$0	#VALUE!	#VALUE!
49		None	$0	#VALUE!	#VALUE!
50		None	$0	#VALUE!	#VALUE!

	2060	Pick Last Improvement to calculate Remaining Service Life ››	Asphalt Reconstruction	Remaining Service Life Cost ››	$6,923,093	$1,885,655	$352,707
		Enter Year of Last Improvement ››	2060				

	Net Present Value ($) @ 3%	Net Present Value ($) @ 7%
NET PRESENT VALUE	$8,442,272	$6,298,973
AGENCY COST	$11,466,373	

Pavement LCCA - I-17 MP 339-340

Deterioration rates

Asphalt	Interstate	Desert Zone	-0.053
Asphalt	Interstate	Other	-0.071
Concrete	Interstate	Desert Zone	-0.027
Concrete	Interstate	Other	-0.033

**For Asphalt - based on Figures 5.5 and 5.8*

**For Concrete - assumed half the asphalt deterioration*

**Based on PMS report 494, developing separte deterioration models for the different traffic and thickness classes are not waranted.*

Enter Name of Design Alternative

		Asphalt Medium Rehab Focus	Agency Cost ($)	Net Present Value @ 3%	Net Present Value @ 7%
0	2015	None	$0	$0	$0
1	2016	None	$0	$0	$0
2	2017	None	$0	$0	$0
3	2018	None	$0	$0	$0
4	2019	None	$0	$0	$0
5	2020	Asphalt Medium Rehab	$1,947,120	$1,729,991	$1,485,449
6	2021	None	$0	$0	$0
7	2022	None	$0	$0	$0
8	2023	None	$0	$0	$0
9	2024	None	$0	$0	$0
10	2025	None	$0	$0	$0
11	2026	None	$0	$0	$0
12	2027	None	$0	$0	$0
13	2028	Asphalt Light Rehab	$1,298,080	$910,447	$576,363
14	2029	None	$0	$0	$0
15	2030	None	$0	$0	$0
16	2031	None	$0	$0	$0
17	2032	None	$0	$0	$0
18	2033	None	$0	$0	$0
19	2034	None	$0	$0	$0
20	2035	Asphalt Reconstruction	$6,923,093	$3,948,143	$1,914,293
21	2036	None	$0	$0	$0
22	2037	None	$0	$0	$0
23	2038	None	$0	$0	$0
24	2039	None	$0	$0	$0
25	2040	None	$0	$0	$0
26	2041	None	$0	$0	$0
27	2042	None	$0	$0	$0
28	2043	None	$0	$0	$0
29	2044	None	$0	$0	$0
30	2045	Asphalt Light Rehab	$1,298,080	$550,836	$182,462
31	2046	None	$0	$0	$0
32	2047	None	$0	$0	$0
33	2048	None	$0	$0	$0
34	2049	None	$0	$0	$0
35	2050	None	$0	$0	$0
36	2051	None	$0	$0	$0
37	2052	None	$0	$0	$0
38	2053	None	$0	$0	$0
39	2054	None	$0	$0	$0
40	2055	Asphalt Medium Rehab	$1,947,120	$614,810	$139,131
41	2056	None	$0	$0	$0
42	2057	None	$0	$0	$0
43	2058	None	$0	$0	$0
44	2059	None	$0	$0	$0
45	2060	None	$0	$0	$0
46		None	$0	#VALUE!	#VALUE!
47		None	$0	#VALUE!	#VALUE!
48		None	$0	#VALUE!	#VALUE!
49		None	$0	#VALUE!	#VALUE!
50		None	$0	#VALUE!	#VALUE!

	2060	Pick Last Improvement to calculate Remaining Service Life ››	Asphalt Medium Rehab	Remaining Service Life Cost ››	$0	$0	$0
		Enter Year of Last Improvement ››	2055				

	Net Present Value ($) @ 3%	Net Present Value ($) @ 7%
NET PRESENT VALUE	$7,754,227	$4,297,698
AGENCY COST	$13,413,493	

Pavement LCCA - I-17 MP 339-340

Deterioration rates

Asphalt	Interstate	Desert Zone	-0.053
Asphalt	Interstate	Other	-0.071
Concrete	Interstate	Desert Zone	-0.027
Concrete	Interstate	Other	-0.033

**For Asphalt - based on Figures 5.5 and 5.8*

**For Concrete - assumed half the asphalt deterioration*

**Based on PMS report 494, developing separte deterioration models for the different traffic and thickness classes are not waranted.*

Enter Name of Design Alternative

		Asphalt Light Rehab Focus	Agency Cost ($)	Net Present Value @ 3%	Net Present Value @ 7%
0	2015	None	$0	$0	$0
1	2016	None	$0	$0	$0
2	2017	None	$0	$0	$0
3	2018	None	$0	$0	$0
4	2019	None	$0	$0	$0
5	2020	Asphalt Light Rehab	$1,298,080	$1,153,327	$990,299
6	2021	None	$0	$0	$0
7	2022	None	$0	$0	$0
8	2023	None	$0	$0	$0
9	2024	None	$0	$0	$0
10	2025	Asphalt Light Rehab	$1,298,080	$994,870	$706,070
11	2026	None	$0	$0	$0
12	2027	None	$0	$0	$0
13	2028	None	$0	$0	$0
14	2029	None	$0	$0	$0
15	2030	Asphalt Light Rehab	$1,298,080	$858,184	$503,418
16	2031	None	$0	$0	$0
17	2032	None	$0	$0	$0
18	2033	None	$0	$0	$0
19	2034	None	$0	$0	$0
20	2035	Asphalt Reconstruction	$6,923,093	$3,948,143	$1,914,293
21	2036	None	$0	$0	$0
22	2037	None	$0	$0	$0
23	2038	None	$0	$0	$0
24	2039	None	$0	$0	$0
25	2040	None	$0	$0	$0
26	2041	None	$0	$0	$0
27	2042	None	$0	$0	$0
28	2043	None	$0	$0	$0
29	2044	None	$0	$0	$0
30	2045	Asphalt Light Rehab	$1,298,080	$550,836	$182,462
31	2046	None	$0	$0	$0
32	2047	None	$0	$0	$0
33	2048	None	$0	$0	$0
34	2049	None	$0	$0	$0
35	2050	None	$0	$0	$0
36	2051	None	$0	$0	$0
37	2052	None	$0	$0	$0
38	2053	None	$0	$0	$0
39	2054	None	$0	$0	$0
40	2055	Asphalt Medium Rehab	$1,947,120	$614,810	$139,131
41	2056	None	$0	$0	$0
42	2057	None	$0	$0	$0
43	2058	None	$0	$0	$0
44	2059	None	$0	$0	$0
45	2060	None	$0	$0	$0
46		None	$0	#VALUE!	#VALUE!
47		None	$0	#VALUE!	#VALUE!
48		None	$0	#VALUE!	#VALUE!
49		None	$0	#VALUE!	#VALUE!
50		None	$0	#VALUE!	#VALUE!
	2060	Asphalt Medium Rehab	$0	$0	$0

Pick Last Improvement to calculate Remaining Service Life ››

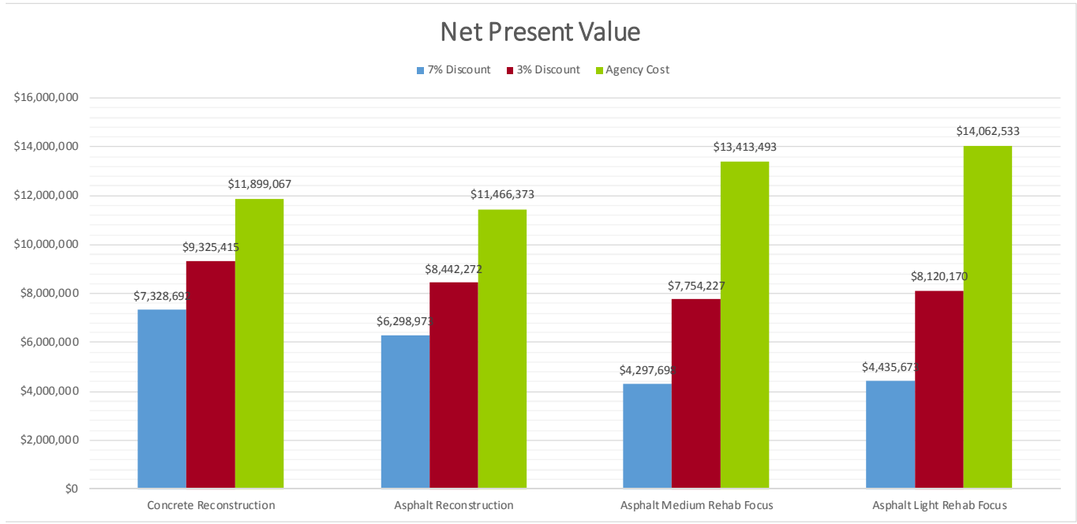
Remaining Service Life Cost ››

Enter Year of Last Improvement ›› 2055

	Net Present Value ($) @ 3%	Net Present Value ($) @ 7%
NET PRESENT VALUE	$8,120,170	$4,435,673
AGENCY COST	$14,062,533	

Project Description	Life-Cycle Cost Analysis for I-17 Corridor Profile Study: MP 339-340
Location #	I-17, Segment 17-12
Milepost Begin	339
Milepost End	340

	Concrete Reconstruction	Asphalt Reconstruction	Asphalt Medium Rehab Focus	Asphalt Light Rehab Focus
Net Present Value - 3%	$9,325,415	$8,442,272	$7,754,227	$8,120,170
Net Present Value - 7%	$7,328,692	$6,298,973	$4,297,698	$4,435,673
Agency Cost	$11,899,067	$11,466,373	$13,413,493	$14,062,533



I-17 Pavement History, MP 339-340

Year	Project Number	Tracs No.	Traffic Directions	Treatment Type	Improvement Descriptions	Thickness (inches)	Beg. MP	End MP	Length (miles)
1966		**PMS01395**	NS	Asphalt Reconstruction	Aggregate Base	4	339.4	339.8	0.40
					Bituminous Treated Surface	2			
1969		**PMS01403**	NS	Plain Portland Concrete	Plain PCCP	9	339.4	340.3	0.92
1991		**H02120**	NS	Rehab	AC with Asphaltic Rubber (AR-AC)	1.5	339.4	340.0	0.60
2003		**H2676**	N	Reconstruction	Aggregate Base	14	339.0	339.6	0.60
					Bituminous Treated Base	4			
					Asphaltic Concrete	9.5			
					ACFC With Asphaltic Rubber (AR-ACFC)	0.5			
					Aggregate Base	10	339.6	339.9	0.30
					Rubberized Membrane (Interlayer or Seal Coat)	4			
					Portland Cement Concrete [DOWELLED]	14			
2003		**H2676**	S	Reconstruction	Aggregate Base	10	338.8	339.8	1.02
					Rubberized Membrane (Interlayer or Seal Coat)	4			
					Portland Cement Concrete [DOWELLED]	14			
					Aggregate Base	14	339.9	340.1	0.20
					Bituminous Treated Base	4			
					Asphaltic Concrete	9.5			
					ACFC With Asphaltic Rubber (AR-ACFC)	0.5			

Life-Cycle Cost Analysis Worksheet

Project Details

Project Description	Life-Cycle Cost Analysis for I-17 Corridor Profile Study: MP 326-334
Location #	I-17, Segment 17-12
Milepost Begin	326
Milepost End	334

Roadway Characteristics

Functional Classification	=	Interstate	
Surface Type	=	Asphalt	‹‹Select from List
Traffic Directions	=	1	‹‹one-way or two-way traffic?
Number of Lanes [each direction]	=	2	
Width of Lanes (ft)	=	12	
Left shoulder width (ft)	=	4	
Right shoulder width (ft)	=	10	
Total Roadway Length (centerline miles)	=	8	
Current PSR Score	=	0	
Current Year	=	2015	
Roadway Width (ft) [each direction lanes & shoulders]	=	38	
Total Lane-Miles [Total traffic direction lanes & shoulders]	=	25.3	
Total Square Feet [Total traffic direction lanes & shoulders]	=	1,605,120	
Total Square Yards [Total traffic direction lanes & shoulders]	=	178,347	

LCCA Parameters

Analysis Period (Years)	=	40
Year of Net Present Value	=	2016
First Year of Improvements	=	2020
Discount Rate (%) - Low	=	3%
Discount Rate (%) - High	=	7%
Number of Design Alternatives	=	6
Trigger Level for Rehabilitation (PSR)	=	3.4

Design Alternatives (DA)

Pavement Material Cost ($)

Treatment Type	Pavement Thickness	Typical Service Life	Lane-miles	Square Feet	Square Yards
Concrete Reconstruction	8"-12"	15-25	$350,000	$5.5	$50
Asphalt Reconstruction	8"-12"	10-20	$280,000	$4.4	$40
Concrete Medium Rehab	1"-3"	11-15	$75,000	$1.2	$11
Concrete Light Rehab	<1"	6-10	$50,000	$0.8	$7
Asphalt Medium Rehab	3"-8"	8-12	$105,000	$1.7	$15
Asphalt Light Rehab	<3"	3-7	$70,000	$1.1	$10

Reconstruction: Other Materials Cost Factor

1.60

Rehab: Other Materials Cost Factor

1.20

Total Cost Factor (e.g., includes design, mobilization, traffic control, contingency, etc.)

2.44

Total Unit Cost ($) [includes material costs and indirect costs] — **Total Bi-Directional Cost ($)**

Treatment Type	Pavement Thickness	Typical Service Life	Lane-miles	Square Feet	Square Yards	Total Cost
Concrete Reconstruction	8"-12"	15-25	$1,366,400	$21.6	$194	$34,615,467
Asphalt Reconstruction	8"-12"	10-20	$1,093,120	$17.3	$155	$27,692,373
Concrete Medium Rehab	1"-3"	11-15	$219,600	$3.5	$31	$5,563,200
Concrete Light Rehab	<1"	6-10	$146,400	$2.3	$21	$3,708,800
Asphalt Medium Rehab	3"-8"	8-12	$307,440	$4.9	$44	$7,788,480
Asphalt Light Rehab	<3"	3-7	$204,960	$3.2	$29	$5,192,320

Pavement LCCA - I-17 MP 326-334

Deterioration rates

Asphalt	Interstate	Desert Zone	-0.053
Asphalt	Interstate	Other	-0.071
Concrete	Interstate	Desert Zone	-0.027
Concrete	Interstate	Other	-0.033

**For Asphalt - based on Figures 5.5 and 5.8*

**For Concrete - assumed half the asphalt deterioration*

**Based on PMS report 494, developing separte deterioration models for the different traffic and thickness classes are not waranted.*

Enter Name of Design Alternative

		Asphalt Reconstruction	Agency Cost ($)	Net Present Value @ 3%	Net Present Value @ 7%
0	2015	None	$0	$0	$0
1	2016	None	$0	$0	$0
2	2017	None	$0	$0	$0
3	2018	None	$0	$0	$0
4	2019	None	$0	$0	$0
5	2020	Asphalt Reconstruction	$27,692,373	$24,604,315	$21,126,379
6	2021	None	$0	$0	$0
7	2022	None	$0	$0	$0
8	2023	None	$0	$0	$0
9	2024	None	$0	$0	$0
10	2025	None	$0	$0	$0
11	2026	None	$0	$0	$0
12	2027	None	$0	$0	$0
13	2028	Asphalt Light Rehab	$5,192,320	$3,641,789	$2,305,452
14	2029	None	$0	$0	$0
15	2030	None	$0	$0	$0
16	2031	None	$0	$0	$0
17	2032	None	$0	$0	$0
18	2033	None	$0	$0	$0
19	2034	None	$0	$0	$0
20	2035	None	$0	$0	$0
21	2036	Asphalt Medium Rehab	$7,788,480	$4,312,293	$2,012,691
22	2037	None	$0	$0	$0
23	2038	None	$0	$0	$0
24	2039	None	$0	$0	$0
25	2040	None	$0	$0	$0
26	2041	None	$0	$0	$0
27	2042	None	$0	$0	$0
28	2043	None	$0	$0	$0
29	2044	Asphalt Light Rehab	$5,192,320	$2,269,442	$780,936
30	2045	None	$0	$0	$0
31	2046	None	$0	$0	$0
32	2047	None	$0	$0	$0
33	2048	None	$0	$0	$0
34	2049	None	$0	$0	$0
35	2050	None	$0	$0	$0
36	2051	None	$0	$0	$0
37	2052	Asphalt Medium Rehab	$7,788,480	$2,687,278	$681,768
38	2053	None	$0	$0	$0
39	2054	None	$0	$0	$0
40	2055	None	$0	$0	$0
41	2056	None	$0	$0	$0
42	2057	None	$0	$0	$0
43	2058	None	$0	$0	$0
44	2059	None	$0	$0	$0
45	2060	Asphalt Reconstruction	$27,692,373	$7,542,621	$1,410,828
46		None	$0	#VALUE!	#VALUE!
47		None	$0	#VALUE!	#VALUE!
48		None	$0	#VALUE!	#VALUE!
49		None	$0	#VALUE!	#VALUE!
50		None	$0	#VALUE!	#VALUE!
	2060	Asphalt Reconstruction	Remaining Service Life Cost ››	$27,692,373	$7,542,621	$1,410,828

Pick Last Improvement to calculate Remaining Service Life ››

Enter Year of Last Improvement ›› 2060

	Net Present Value ($) @ 3%	Net Present Value ($) @ 7%
NET PRESENT VALUE	$37,515,117	$26,907,227
AGENCY COST	$53,653,973	

Pavement LCCA - I-17 MP 326-334

Deterioration rates

Asphalt	Interstate	Desert Zone	-0.053
Asphalt	Interstate	Other	-0.071
Concrete	Interstate	Desert Zone	-0.027
Concrete	Interstate	Other	-0.033

**For Asphalt - based on Figures 5.5 and 5.8*

**For Concrete - assumed half the asphalt deterioration*

**Based on PMS report 494, developing separte deterioration models for the different traffic and thickness classes are not waranted.*

Enter Name of Design Alternative

		Asphalt Medium Rehab Focus	Agency Cost ($)	Net Present Value @ 3%	Net Present Value @ 7%
0	2015	None	$0	$0	$0
1	2016	None	$0	$0	$0
2	2017	None	$0	$0	$0
3	2018	None	$0	$0	$0
4	2019	None	$0	$0	$0
5	2020	Asphalt Medium Rehab	$7,788,480	$6,919,964	$5,941,794
6	2021	None	$0	$0	$0
7	2022	None	$0	$0	$0
8	2023	None	$0	$0	$0
9	2024	None	$0	$0	$0
10	2025	None	$0	$0	$0
11	2026	None	$0	$0	$0
12	2027	None	$0	$0	$0
13	2028	Asphalt Light Rehab	$5,192,320	$3,641,789	$2,305,452
14	2029	None	$0	$0	$0
15	2030	None	$0	$0	$0
16	2031	None	$0	$0	$0
17	2032	None	$0	$0	$0
18	2033	Asphalt Light Rehab	$5,192,320	$3,141,439	$1,643,756
19	2034	None	$0	$0	$0
20	2035	None	$0	$0	$0
21	2036	None	$0	$0	$0
22	2037	None	$0	$0	$0
23	2038	Asphalt Medium Rehab	$7,788,480	$4,064,749	$1,757,962
24	2039	None	$0	$0	$0
25	2040	None	$0	$0	$0
26	2041	None	$0	$0	$0
27	2042	None	$0	$0	$0
28	2043	None	$0	$0	$0
29	2044	None	$0	$0	$0
30	2045	None	$0	$0	$0
31	2046	Asphalt Reconstruction	$27,692,373	$11,408,891	$3,637,867
32	2047	None	$0	$0	$0
33	2048	None	$0	$0	$0
34	2049	None	$0	$0	$0
35	2050	None	$0	$0	$0
36	2051	None	$0	$0	$0
37	2052	None	$0	$0	$0
38	2053	None	$0	$0	$0
39	2054	Asphalt Light Rehab	$5,192,320	$1,688,678	$396,988
40	2055	None	$0	$0	$0
41	2056	None	$0	$0	$0
42	2057	None	$0	$0	$0
43	2058	None	$0	$0	$0
44	2059	None	$0	$0	$0
45	2060	None	$0	$0	$0
46		None	$0	#VALUE!	#VALUE!
47		None	$0	#VALUE!	#VALUE!
48		None	$0	#VALUE!	#VALUE!
49		None	$0	#VALUE!	#VALUE!
50		None	$0	#VALUE!	#VALUE!

	2060	Pick Last Improvement to calculate Remaining Service Life ››	Asphalt Light Rehab	Remaining Service Life Cost ››	$0	$0	$0
		Enter Year of Last Improvement ››	2054				

	Net Present Value ($) @ 3%	Net Present Value ($) @ 7%
NET PRESENT VALUE	$30,865,510	$15,683,820
AGENCY COST	$58,846,293	

Pavement LCCA - I-17 MP 326-334

Deterioration rates

Asphalt	Interstate	Desert Zone	-0.053
Asphalt	Interstate	Other	-0.071
Concrete	Interstate	Desert Zone	-0.027
Concrete	Interstate	Other	-0.033

**For Asphalt - based on Figures 5.5 and 5.8*

**For Concrete - assumed half the asphalt deterioration*

**Based on PMS report 494, developing separte deterioration models for the different traffic and thickness classes are not waranted.*

Enter Name of Design Alternative

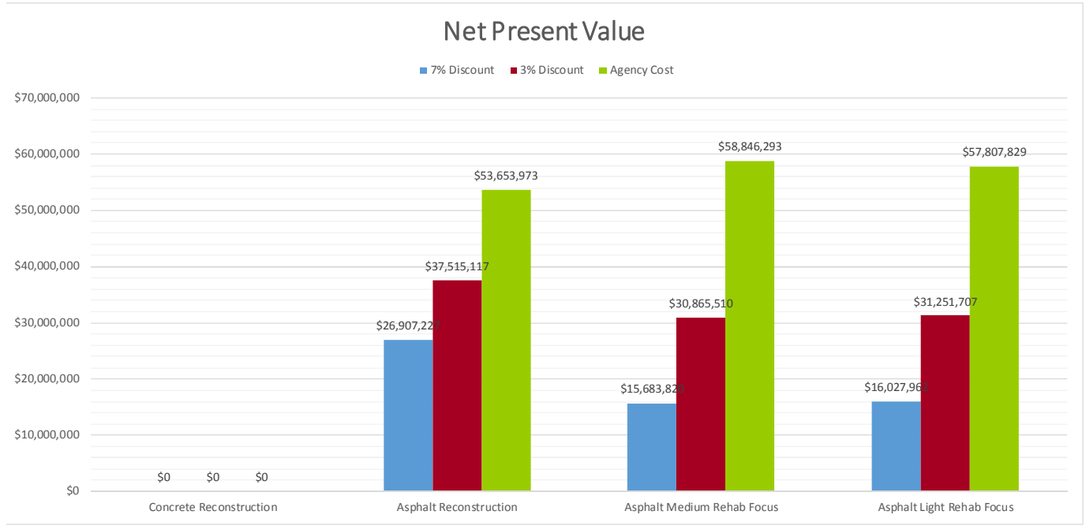
		Asphalt Light Rehab Focus	Agency Cost ($)	Net Present Value @ 3%	Net Present Value @ 7%
0	2015	None	$0	$0	$0
1	2016	None	$0	$0	$0
2	2017	None	$0	$0	$0
3	2018	None	$0	$0	$0
4	2019	None	$0	$0	$0
5	2020	Asphalt Light Rehab	$5,192,320	$4,613,309	$3,961,196
6	2021	None	$0	$0	$0
7	2022	None	$0	$0	$0
8	2023	None	$0	$0	$0
9	2024	None	$0	$0	$0
10	2025	Asphalt Light Rehab	$5,192,320	$3,979,481	$2,824,278
11	2026	None	$0	$0	$0
12	2027	None	$0	$0	$0
13	2028	None	$0	$0	$0
14	2029	None	$0	$0	$0
15	2030	Asphalt Medium Rehab	$7,788,480	$5,149,103	$3,020,507
16	2031	None	$0	$0	$0
17	2032	None	$0	$0	$0
18	2033	None	$0	$0	$0
19	2034	None	$0	$0	$0
20	2035	None	$0	$0	$0
21	2036	None	$0	$0	$0
22	2037	None	$0	$0	$0
23	2038	Asphalt Light Rehab	$5,192,320	$2,709,833	$1,171,975
24	2039	None	$0	$0	$0
25	2040	None	$0	$0	$0
26	2041	None	$0	$0	$0
27	2042	None	$0	$0	$0
28	2043	Asphalt Reconstruction	$27,692,373	$12,466,803	$4,456,544
29	2044	None	$0	$0	$0
30	2045	None	$0	$0	$0
31	2046	None	$0	$0	$0
32	2047	None	$0	$0	$0
33	2048	None	$0	$0	$0
34	2049	None	$0	$0	$0
35	2050	None	$0	$0	$0
36	2051	Asphalt Light Rehab	$5,192,320	$1,845,264	$486,328
37	2052	None	$0	$0	$0
38	2053	None	$0	$0	$0
39	2054	None	$0	$0	$0
40	2055	None	$0	$0	$0
41	2056	None	$0	$0	$0
42	2057	None	$0	$0	$0
43	2058	None	$0	$0	$0
44	2059	Asphalt Medium Rehab	$7,788,480	$2,185,003	$424,571
45	2060	None	$0	$0	$0
46		None	$0	#VALUE!	#VALUE!
47		None	$0	#VALUE!	#VALUE!
48		None	$0	#VALUE!	#VALUE!
49		None	$0	#VALUE!	#VALUE!
50		None	$0	#VALUE!	#VALUE!

	2060	Pick Last Improvement to calculate Remaining Service Life ››	Asphalt Medium Rehab	Remaining Service Life Cost ››	$6,230,784	$1,697,090	$317,436
		Enter Year of Last Improvement ››	2059				

	Net Present Value ($) @ 3%	Net Present Value ($) @ 7%
NET PRESENT VALUE	$31,251,707	$16,027,962
AGENCY COST	$57,807,829	

Project Description	Life-Cycle Cost Analysis for I-17 Corridor Profile Study: MP 326-334
Location #	I-17, Segment 17-12
Milepost Begin	326
Milepost End	334

	Concrete Reconstruction	Asphalt Reconstruction	Asphalt Medium Rehab Focus	Asphalt Light Rehab Focus
Net Present Value - 3%	#DIV/0!	$37,515,117	$30,865,510	$31,251,707
Net Present Value - 7%	#DIV/0!	$26,907,227	$15,683,820	$16,027,962
Agency Cost	#DIV/0!	$53,653,973	$58,846,293	$57,807,829



I-17 Pavement History, MP 326-334 Northbound

Year	Project Number	Tracs No.	Traffic Directions	Treatment Type	Improvement Descriptionts	Thickness (inches)	Beg. MP	End MP	Length (miles)
1961		**PMS01389**	N	Asphalt Reconstruction	Aggregate Base	9	325.9	334.3	8.45
					Bituminous Treated Surface	5	325.9	334.3	8.45
					Seal Coat - Cover Material With Emulsified Asphalt [0.3	2	325.9	334.3	8.45
1966		**PMS01401**	N	Asphalt Medium Rehab	Asphaltic Concrete	5.5	319.0	336.0	17.00
					Seal Coat - Cover Material With Emulsified Asphalt [0.3	0.3	319.0	336.0	17.00
1974		**PMS01394**	N	Asphalt Light Rehab	ACFC Asphaltic Concrete Friction Course	0.5	326.5	335.9	9.40
1988		**H02060**	N	Asphalt Medium Rehab	Remove Existing Material	3	324.0	334.6	10.58
					Asphaltic Concrete	3	324.0	334.6	10.58
					Asphaltic Concrete	1.5	324.0	334.6	10.58
					ACFC Asphaltic Concrete Friction Course	0.5	324.0	334.6	10.58
1999		**H4976**	N	Asphalt Medium Rehab	Remove Existing Material	4	312.0	339.0	27.00
					AC	4	312.0	339.0	27.00
					ACFC With Asphaltic Rubber (AR-ACFC) [0.5 to 1.0]	0.7	312.0	339.0	27.00
2008		**H7610**	N	Asphalt Light Rehab	Microseal		326.9	338.0	11.10
2009		**H77885**	N	Asphalt Light Rehab	Microseal		326.9	338.0	11.10

BENEFIT COST ANALYSIS

Introduction

The improvement alternatives evaluated in this Benefit Cost Analysis (BCA) would support the region's economy over the long-term by providing the highway users with improved capacity, generating travel time savings, incident time savings, auto and truck emissions reductions, and the reduced likelihood for accidents. In addition, the investments would have residual value that extends beyond the analysis period. The balance of this discussion describes the assumptions and methods used to develop the BCA and estimates the value of the long-term benefits generated by the investment.

All benefits are estimated in accordance with guidance provided by US Department of Transportation (USDOT) for BCAs. If no USDOT guidance was available for the estimate, the Project team consulted industry research for the best practice and information on which to base the assumptions and methods.

General Assumptions

A number of general assumptions were used throughout the analysis, including:

- Discount rates of 3% and 7% were used. Projects hoping to receive federal funds must show a 7% discount rate, and a 3% rate is shown for comparison as a representation of the economic climate of recent years.
- Construction takes place over 2020-2021
- Analysis period is 2020-2039, or 20 full years of operation
- All costs and benefits are discounted to 2016
- All values are in 2015 dollars
- Annualization factor to convert daily traffic volumes to annual volumes is assumed to be 270 days in one year

Travel Market Effects

The methodology for each of the travel market effects is described in this section. The travel market benefits include safety, travel time savings, incident delay savings, and emissions savings. Residual effects are discussed following the travel market effects.

Safety Benefits

It is anticipated that the improvement alternatives would result in a reduction in accidents along the segment being evaluated. The analysis considers the change in incapacitating injuries and fatalities that result from crashes involving single vehicles, sideswipes, rear end collisions, and other incidents.

The rates of crashes that result in fatalities and incapacitating injuries between the No Build and improvement alternatives were used to estimate the reduction in fatal and incapacitating crashes. The difference between the annual fatal and incapacitating injuries for the No Build and improvement alternatives are assumed to grow by a conservative 1% per year, indicating that these incidents are avoided by an increasing 1% of drivers. The 2014 existing value of crashes used for the No Build was escalated to 2020 by 1% per year to be comparable to the 2020 crashes for the improvement alternatives.

The total annual fatal and incapacitating injuries for the Black Canyon Hill location are shown in Table 1.

Table 1 – Black Canyon Hill Safety Data, 2020

	Avg. per year, fatal crashes	Avg. per year, Incapacitating crashes
Existing	1.27	1.27
Climbing Lane	0.92	0.90
2 Reversible Lanes	0.79	0.83
Shoulder Running	0.93	0.93

The total annual value for injury severity is based on USDOT guidance and the National Highway Safety Council estimates for the value of avoiding a crash. These estimates are applied to the number of crashes avoided to estimate the total value of crashes avoided. Table 2 provides the estimated cost of different types of injuries. Because the injuries from crashes are given as fatalities and incapacitating injuries, the value of incapacitating injuries is assumed to be MAIS 4, or severe, for this analysis. Per guidance,[1] the value of injuries avoided is escalated by 1.18% per year throughout the period of analysis.

Table 2 - Value of Injury Avoided, in $2015M

Value of Accidents Avoided	2015$ Millions
Value of Statistical Life, 2013	$9.67
MAIS 5 Critical (0.593) Fraction of VSL	$5.74
MAIS 4 Severe (0.266) Fraction of VSL	$ 2.57
MAIS 3 Serious (0.105) Fraction of VSL	$1.02
MAIS 2 Moderate (0.047) Fraction of VSL	$0.45
MAIS 1 Minor (0.003) Fraction of VSL	$0.03
No Injury, 2010	$0.00

Source: 2015 OST Guidance, see http://www.transportation.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

[1] Source: U.S. Department of Transportation. Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analyses – 2014 Adjustment from https://www.transportation.gov/sites/dot.gov/files/docs/VSL_Guidance_2014.pdf

Table 3 shows the total value of the reduction in highway fatalities and incapacitating injuries for each alternative in the Black Canyon Hill location.

Table 3 – Black Canyon Hill Safety Benefits, $2015M

	Discounted at 7%	Discounted at 3%
Climbing Lane	$ 56.13	$ 90.75
2 Reversible Lanes	$ 63.02	$ 101.89
Shoulder Running	$ 45.88	$ 74.18

Travel Time Savings

The improvement alternatives would result in slight speed increases during peak times at the Black Canyon Hill location, which would result in travel time savings for users.

The No Build travel time is estimated as the No Build speed divided by the effective distance of the improvement, which is 6 miles for each alternative. The same is done for the estimated speed for the alternatives. The difference between the travel time in the No Build and improvement alternatives is the time saved per vehicle.

Peak traffic volumes in the northbound and southbound direction were given for existing traffic in 2014 and for the improvement alternatives in 2035 from the travel demand model. The volumes were interpolated straight-line to get the in-between years, and are assumed to grow at a conservative 1% per year after 2035.

To calculate the travel time costs, the time was allocated by trip purpose (business or personal). It is assumed that all auto traffic is personal time, and all truck traffic is for business purposes. The value of time for truck and auto travel was based on USDOT guidance, and grows at 1.2% per year[2]. The value of time in 2020 is shown in Table 6.

Table 4 – Value of Time per Person per Hour by Mode, $2015

	2020
Truck	$28.18
Auto	$19.11

The shares of truck and auto traffic by alternative are shown in Table 5.

Table 5 – Shares of Truck and Auto Traffic for Black Canyon Hill

	Climbing Lane	2 Reversible Lanes	Shoulder Running
% Truck	13.0%	13.0%	13.0%
% Auto	87.0%	87.0%	87.0%

[2] Source: U.S. Department of Transportation. (2015). Revised Guidance on Valuation of Travel Time in Economic Analysis. Retrieved 2015, from https://www.transportation.gov/sites/dot.gov/files/docs/USDOT%20VOT%20Guidance%202014.pdf

Additionally, the number of people traveling in the vehicle must be factored into the value of the travel time savings because passengers also would benefit. The average auto occupancy used in the analysis is 1.55[3]. All peak auto trips, therefore, are multiplied by 1.55 to account for passengers in the vehicle. It is assumed that truck drivers travel alone, so the average truck occupancy rate is 1.0. Multiplying the peak travel time reduction by the value of time by mode, occupancy rates, and shares of truck and auto traffic yields the total travel time savings by alternative.

Table 6 shows the travel time savings for the Black Canyon Hill location.

Table 6 – Black Canyon Hill Travel Time Savings, $2015M

	Discounted at 7%	Discounted at 3%
Climbing Lane	$ 0.04	$ 0.06
2 Reversible Lanes	$ 0.06	$ 0.10
Shoulder Running	$ 0.04	$ 0.06

Incident Delay Savings

When incidents such as emergencies occur on the highway, delays occur for the other travelers on the segment. It is anticipated that users would experience fewer incident delays under the improvement alternatives than the No Build. This reduction in incidents experienced is travel time savings for the users. The hours of incidents avoided per year by alternative are shown in Table 7 for 2035. No incidents are avoided prior to 2020, and the hours are interpolated straight-line to get the annual hours of incident delay avoided over the analysis period. Benefits are assumed to start accruing in 2020 and grow by 1% per year after 2035.

Table 7 – Black Canyon Hill Hours of Incidents Avoided per Year in 2035

	Hours of Incidents Avoided
Climbing Lane	54,000
2 Reversible Lanes	286,000
Shoulder Running	53,000

Multiplying the annual hours of incident delay avoided by the share of truck and auto traffic and their respective values of time (as described in the Travel Time Savings section) results in the total value of incident delays avoided. The total incident delays avoided are shown in Table 8 for Black Hill Canyon.

[3] Average auto occupancy from the 2009 National Household Travel Survey for autos, from http://nhts.ornl.gov/tables09/fatcat/2009/avo_TRPTRANS_WHYTRP1S.html

Table 8 – Black Canyon Hill Value of Incident Delays Avoided, $2015M

	Discounted at 7%	Discounted at 3%
Climbing Lane	$11.58	$18.88
2 Reversible Lanes	$69.38	$113.41
Shoulder Running	$11.26	$18.40

Highway Emissions Benefits

The highway delays associated with incidents also cause idling vehicles to emit pollutants into the atmosphere. With the avoidance of incident delays as previously described, emissions would be reduced.

Decreased amounts of CO, NOx, PM2.5, PM10, VOC, CO2, and THC come from the US Environmental Protection Agency's (EPA) Office of Transportation and Air Quality published idle emissions factors for autos and trucks (g/hr.) for various pollutant types[4]. See Table 9 for the emissions rates used in the analysis.

Table 9 – Idle Emission Rates (Grams per Hour)

	CO	NOX	PM2.5	PM10	VOC	CO2	THC
LDGV (Auto)	71.225	3.515			2.683	8887	3.163
Heavy Duty Diesel, VIIIb (Truck)	34.473	42.345	1.114	1.211	4.218	10180	4.27

Source: US EPA, Office of Transportation and Air Quality, Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks, EPA420-F-08-025, October 2008, Table 1, http://www.epa.gov/otaq/consumer/420f08025.pdf

Since the emission rates are based on hours, the emission rate was multiplied by the annual hours saved for each alternative, consistent with the Incidents Avoided Benefit. The grams were converted to short tons and valued by applying the economic cost of air emissions to the reduction of CO, NOx, PM2.5, PM10, VOC, and CO2, as recommended in the US DOT 2015 TIGER BCA Resource Guide[5] and shown in Table 10. THC was valued using the default value in FRA's GradeDec.NET model for highway-rail grade crossing investment analysis[6].

Table 10 – Economic Cost of Air Emissions, 2015$

	2015$	Unit
Carbon Monoxide	$0	$/short ton
Volatile Organic Compounds	$1,865	$/short ton
Nitrogen Oxides	$7,354	$/short ton
Particulate Matter	$336,394	$/short ton
Carbon Dioxide*	*Varies, $56.40 (2020)*	$/metric ton
Hydrocarbons (THC)**	$2,040	$/short ton

Note: The Resource Guide converts these values into 2013 dollars. Escalated to 2015$ using the GDP Deflator
*CO2 value varies and is shown for 2020
**Hydrocarbons sourced from GradeDec default value
Source: Corporate Average Fuel Economy for MY2017-MY2025 Passenger Cars and Light Trucks (August 2012), page 922, http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/FRIA_2017-2025.pdf
TIGER 2015 BCA Resource Guide: http://www.dot.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

The results of the emissions reductions for the Black Canyon Hill location are shown in Table 11 followed by the CO2 reduction results, which are only discounted at 3%.

Table 11 – Black Canyon Hill Value of Emissions Avoided, $2015M

	Discounted at 7%	Discounted at 3%
Climbing Lane	$0.08	$0.13
2 Reversible Lanes	$0.42	$0.67
Shoulder Running	$0.08	$0.13

Table 12 – Black Canyon Hill Value of CO2 Avoided, $2015M

	Discounted at 3%
Climbing Lane	$0.39
2 Reversible Lanes	$2.09
Shoulder Running	$0.38

Residual Effects

Residual Value

Construction of the new highway and bridges associated with the road right of way would have residual value after the end of the 20-year analysis period, because the useful life of these elements is longer than 20 years. The useful life of highways and streets is 60 years. The values

[4] Source: US EPA, Office of Transportation and Air Quality, Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks, EPA420-F-08-025, October 2008, Table 1, http://www.epa.gov/otaq/consumer/420f08025.pdf

[5] TIGER Benefit-Cost Analysis Resource Guide (updated April 2, 2015), http://www.dot.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

[6] HC valued at $2,040 per ton, assumed to be 2015 dollars.

of the highway projects were depreciated straight-line over the 60 years[7], assuming that 60% of the total capital costs are for highway construction. The first 20 years of depreciation were excluded from the residual estimation as they are the basis of the benefits estimated elsewhere in the analysis; while, the remaining 40 years were discounted at 7% and 3%.

Finally, right of way does not depreciate, so the value of the right of way acquired for the alternatives, which is assumed to be 5% of the capital costs, was also included in the residual analysis.

The total residual results for the Black Canyon Hill location are shown in Table 13.

Table 13 – Black Canyon Hill Residual Benefit, 2015$M

	Discounted at 7%	Discounted at 3%
Climbing Lane	$ 4.56	$11.38
2 Reversible Lanes	$13.20	$32.94
Shoulder Running	$4.52	$11.28

Costs

Capital Costs

The capital costs for the alternatives include the costs for the local roadway modifications and bridges. The capital costs are applied over the two year construction period for the alternatives, assumed to begin January 2020 and ending December 2021 for all alternatives. Costs are assumed to be expended 50% in 2020 and 50% in 2021 for all alternatives. The costs for the Black Canyon Hill alternatives are shown in Table 14

Table 14 – Black Canyon Hill Capital Costs, 2015$

	Climbing Lane	2 Reversible Lanes	Shoulder Running
Total Project Costs	$51,420,000	$148,820,000	$50,960,000

Operating and Maintenance Costs

Each of the improvement alternatives requires annual and periodic operating and maintenance (O&M) costs to keep the roads and bridges up to code. It is assumed that the O&M for each alternative would cost 1% of the total capital cost per year for 2025-2039. It is assumed there are no O&M costs for 2020-2024. The annual O&M costs for Black Canyon Hill are shown in Table 15.

Table 15– Black Canyon Hill Annual O&M Costs, 2015$

	Annual O&M, $M
Climbing Lane	$0.51
2 Reversible Lanes	$1.49
Shoulder Running	$0.51

Summary

Table 16 summarizes the discounted value of the benefits discussed in this memorandum. Taken in total, the benefits – residual savings, safety savings, emissions savings, CO2 reductions, incident delay savings, and travel time savings –provide greater benefits than costs for all alternatives under all discount rates.

[7] BEA Rate of Depreciation, Service Lives, Declining-Balance Rates, and Hulten-Wykoff Categories, http://www.bea.gov/scb/account_articles/national/wlth2594/tableC.htm

Table 16 – Black Canyon Hill Benefit Cost Analysis

	Climbing Lane		2 Reversible Lanes		Shoulder Running	
	20 Year Analysis Period (2020 -2039)					
	Values stated in 2015 $M					
	Discounted at 7%	Discounted at 3%	Discounted at 7%	Discounted at 3%	Discounted at 7%	Discounted at 3%
Costs						
Capital Costs	$37.94	$45.02	$109.82	$130.30	$37.61	$44.62
O&M Costs	$2.73	$4.85	$7.89	$14.02	$2.70	$4.80
Total Costs	***$40.67***	***$49.87***	***$117.71***	***$144.32***	***$40.31***	***$49.42***
Benefits						
Travel Market Effects						
Safety Savings	$56.13	$90.75	$63.02	$101.89	$45.88	$74.18
Emissions Savings	$0.08	$0.13	$0.42	$0.67	$0.08	$0.13
CO2 Reductions	$0.39	$0.39	$2.09	$2.09	$0.38	$0.38
Incident Delay Avoided	$11.58	$18.88	$69.38	$113.41	$11.26	$18.40
Travel Time Savings	$0.04	$0.06	$0.06	$0.10	$0.04	$0.06
Residual Effects						
Residual Value	$4.56	$11.38	$13.20	$32.94	$4.52	$11.28
Total Benefits	***$72.78***	***$121.60***	***$148.17***	***$251.12***	***$62.15***	***$104.43***
BC Ratio	**1.79**	**2.44**	**1.26**	**1.74**	**1.54**	**2.11**

*Climate Change (CO2) benefits are only discounted at 3% per Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon, Feb 2010

Capital Costs

Discount Rates	3%
	7%
Discount year	2016

I-17 Location 1 Black Canyon Hill Inputs

Cost Category	Climbing Lane	2 Reversible Lanes	Shoulder Running
Total Project Costs	$ 51,420,000	$ 148,820,000	$ 50,960,000
Values in $2015			

Assumes all Alternatives have the same spending schedule	2020	2021	2022
Assumes the following distribution of costs across the years:	50%	50%	0%

I-17 Location 1 Black Canyon Hill Outputs

Climbing Lane

	2020	2021	2022
Total	**$ 25,710,000**	**$ 25,710,000**	**$ -**

Total	**$ 25,710,000**	**$ 25,710,000**	**$ -**
Discounted at 3%	$ 22,843,002	$ 22,177,672	$ -
Discounted at 7%	$ 19,614,036	$ 18,330,875	$ -

Capital Cost Summary	Total ($M)
Total	$ 51.42
Discounted at 3%	$ 45.02
Discounted at 7%	$ 37.94

2 Reversible Lanes

	2020	2021	2022
Total	**$ 74,410,000**	**$ 74,410,000**	**$ -**

Total	**$ 74,410,000**	**$ 74,410,000**	**$ -**
Discounted at 3%	$ 66,112,321	$ 64,186,720	$ -
Discounted at 7%	$ 56,767,033	$ 53,053,302	$ -

Capital Cost Summary	Total ($M)
Total	$ 148.82
Discounted at 3%	$ 130.30
Discounted at 7%	$ 109.82

Shoulder Running

	2020	2021	2022
Total	**$ 25,480,000**	**$ 25,480,000**	**$ -**

Total	**$ 25,480,000**	**$ 25,480,000**	**$ -**
Discounted at 3%	$ 22,638,650	$ 21,979,272	$ -
Discounted at 7%	$ 19,438,570	$ 18,166,888	$ -

Capital Cost Summary	Total ($M)
Total	$ 50.96
Discounted at 3%	$ 44.62
Discounted at 7%	$ 37.61

O&M Costs

Assume O&M is 1% of Capital, per year for 2025-2039. Assume no O&M costs for 2020-2025. Assumes no change over analysis period.

Discount	0.03
	0.07
Discount year	2016

I-17 Location 1 Black Canyon Hill

Climbing Lane 1%

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Annual O&M Costs (in millions of 2015$)	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
O&M Costs						$514,200	$514,200	$514,200	$514,200	$514,200	$514,200	$514,200	$514,200	$514,200	$514,200	$514,200	$514,200	$514,200	$514,200	$514,200
Total	**$0**	**$0**	**$0**	**$0**	**$0**	**$514,200**	**$514,200**	**$514,200**	**$514,200**	**$514,200**	**$514,200**	**$514,200**	**$514,200**	**$514,200**	**$514,200**	**$514,200**	**$514,200**	**$514,200**	**$514,200**	**$514,200**
Discounted 7%	$0	$0	$0	$0	$0	$279,691	$261,393	$244,293	$228,311	$213,375	$199,416	$186,370	$174,177	$162,783	$152,133	$142,181	$132,879	$124,186	$116,062	$108,469
Discounted 3%	$0	$0	$0	$0	$0	$394,091	$382,613	$371,469	$360,650	$350,145	$339,947	$330,045	$320,432	$311,099	$302,038	$293,241	$284,700	$276,408	$268,357	$260,541

	20 year Total (2020-2039)
Millions of 2015$	$7.71
Discounted 7%	$2.73
Discounted 3%	$4.85

2 Reversible Lanes 1%

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Annual O&M Costs (in millions of 2015$)	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
O&M Costs						$1,488,200	$1,488,200	$1,488,200	$1,488,200	$1,488,200	$1,488,200	$1,488,200	$1,488,200	$1,488,200	$1,488,200	$1,488,200	$1,488,200	$1,488,200	$1,488,200	$1,488,200
Total	**$0**	**$0**	**$0**	**$0**	**$0**	**$1,488,200**	**$1,488,200**	**$1,488,200**	**$1,488,200**	**$1,488,200**	**$1,488,200**	**$1,488,200**	**$1,488,200**	**$1,488,200**	**$1,488,200**	**$1,488,200**	**$1,488,200**	**$1,488,200**	**$1,488,200**	**$1,488,200**
Discounted 7%	$0	$0	$0	$0	$0	$809,482	$756,525	$707,033	$660,779	$617,550	$577,150	$539,392	$504,105	$471,126	$440,305	$411,500	$384,579	$359,420	$335,906	$313,931
Discounted 3%	$0	$0	$0	$0	$0	$1,140,581	$1,107,361	$1,075,107	$1,043,794	$1,013,392	$983,876	$955,219	$927,397	$900,385	$874,161	$848,700	$823,980	$799,981	$776,680	$754,059

	20 year Total (2020-2039)
Millions of 2015$	$22.32
Discounted 7%	$7.89
Discounted 3%	$14.02

Shoulder Running 1%

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Annual O&M Costs (in millions of 2015$)	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
O&M Costs						$509,600	$509,600	$509,600	$509,600	$509,600	$509,600	$509,600	$509,600	$509,600	$509,600	$509,600	$509,600	$509,600	$509,600	$509,600
Total	**$0**	**$0**	**$0**	**$0**	**$0**	**$509,600**	**$509,600**	**$509,600**	**$509,600**	**$509,600**	**$509,600**	**$509,600**	**$509,600**	**$509,600**	**$509,600**	**$509,600**	**$509,600**	**$509,600**	**$509,600**	**$509,600**
Discounted 7%	$0	$0	$0	$0	$0	$277,189	$259,055	$242,107	$226,268	$211,466	$197,632	$184,702	$172,619	$161,326	$150,772	$140,909	$131,690	$123,075	$115,023	$107,499
Discounted 3%	$0	$0	$0	$0	$0	$390,566	$379,190	$368,146	$357,423	$347,013	$336,906	$327,093	$317,566	$308,316	$299,336	$290,618	$282,153	$273,935	$265,956	$258,210

	20 year Total (2020-2039)
Millions of 2015$	$7.64
Discounted 7%	$2.70
Discounted 3%	$4.80

Residual Value

Discount	3%
	7%
Discount year	2016

Type of asset	Service life (years)	Hulten-Wykoff category
Highways and streets	60	C

Source: BEA Rate of Depreciation, Service Lives, Declining-Balance Rates, and Hulten-Wykoff Categories
http://www.bea.gov/scb/account_articles/national/wlth2594/tableC.htm

I-17 Location 1 Black Canyon Hill

Climbing Lane

	2015 $		
ROW does not depreciate	$ 2,571,000	5%	Assumed percentage of capital costs for ROW
		2040	
Highways and streets	$ 30,852,000	60%	Assumed percentage of capital costs for highway construction
Total Value Remaining after 2039	$ 20,568,000	$ 23,139,000	
Discounted at 3%		$ 11,382,855	
Discounted at 7%		$ 4,561,776	

Residual Summary	Total ($M)
Total	$ 23.14
Discounted at 3%	$ 11.38
Discounted at 7%	$ 4.56

2 Reversible Lanes

	2015 $		
ROW does not depreciate	$ 7,441,000	5%	Assumed percentage of capital costs for ROW
		2040	
Highways and streets	$ 89,292,000	60%	Assumed percentage of capital costs for highway construction
Total Value Remaining after 2039	$ 59,528,000	$ 66,969,000	
Discounted at 3%		$ 32,944,310	
Discounted at 7%		$ 13,202,712	

Residual Summary	Total ($M)
Total	$ 66.97
Discounted at 3%	$ 32.94
Discounted at 7%	$ 13.20

Shoulder Running

	2015 $		
ROW does not depreciate	$ 2,548,000	5%	Assumed percentage of capital costs for ROW
		2040	
Highways and streets	$ 30,576,000	60%	Assumed percentage of capital costs for highway construction
Total Value Remaining after 2039	$ 20,384,000	$ 22,932,000	
Discounted at 3%		$ 11,281,024	
Discounted at 7%		$ 4,520,966	

Residual Summary	Total ($M)
Total	$ 22.93
Discounted at 3%	$ 11.28
Discounted at 7%	$ 4.52

Safety Costs Avoided

Value of accidents avoided

Value of Accidents Avoided	**2013$ Millions**	**2015$ Millions**	
Value of Statistical Life, 2013	$ 9.400	$ 9.672	Guidance on Treatment of the Economic Value of a Statistical Life in the US, Department of Transportation Analyses 2014
MAIS 5 Critical (0.593) Fraction of VSL	$ 5.574	$ 5.735	Guidance on Treatment of the Economic Value of a Statistical Life in the US, Department of Transportation Analyses 2014
MAIS 4 Severe (0.266) Fraction of VSL	$ 2.500	$ 2.573	Guidance on Treatment of the Economic Value of a Statistical Life in the US, Department of Transportation Analyses 2014

Source: VSL, 2013 -- Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in USDOT Analyses

2015 OST Guidance, see http://www.transportation.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

Increase VSL by 1.18% per Year per Guidance 1.18%

Source: U.S. Department of Transportation. (2015). Guidance on Treatment of the Economic Value of a Statistical Life. Retrieved 2015, from http://www.transportation.gov/sites/dot.gov/files/docs/Revised%20Departmental%20Guidance%20on%20Valuation%20of%20Travel%20Time%20in%20Economic%20Analysis.pdf

$Millions of 2015 dollars

2015	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
VSL	$ 10.256	$ 10.377	$ 10.500	$ 10.624	$ 10.749	$ 10.876	$ 11.004	$ 11.134	$ 11.265	$ 11.398	$ 11.533	$ 11.669	$ 11.807	$ 11.946	$ 12.087	$ 12.229	$ 12.374	$ 12.520	$ 12.668	$ 12.817
MAIS 5 Critical (0.593) Fraction of VSL	$ 6.082	$ 6.154	$ 6.226	$ 6.300	$ 6.374	$ 6.449	$ 6.525	$ 6.602	$ 6.680	$ 6.759	$ 6.839	$ 6.920	$ 7.001	$ 7.084	$ 7.167	$ 7.252	$ 7.338	$ 7.424	$ 7.512	$ 7.600
MAIS 4 Severe (0.266) Fraction of VSL	$ 2.728	$ 2.760	$ 2.793	$ 2.826	$ 2.859	$ 2.893	$ 2.927	$ 2.962	$ 2.997	$ 3.032	$ 3.068	$ 3.104	$ 3.141	$ 3.178	$ 3.215	$ 3.253	$ 3.291	$ 3.330	$ 3.370	$ 3.409

Discount Rates		Discount Year
0.03	0.07	2016

I-17 Location 1 Black Canyon Hill

Climbing Lane

Baseline Safety

2020	
Average Annual Fatal	1.27
Average Annual Incapacitating	1.27

Note: assume incapacitating are MAIS 4 (severe) injuries

Future Safety

2020	
Average Annual Fatal	0.88
Average Annual Incapacitating	0.72

Note: assume incapacitating are MAIS 4 (severe) injuries

Annual growth factor for incidents (thus a reduction in incidents avoided) 1%

	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
Reduced Fatal Accidents	0.39	0.39	0.40	0.40	0.41	0.41	0.41	0.42	0.42	0.43	0.43	0.43	0.44	0.44	0.45	0.45	0.46	0.46	0.47	0.47
Reduced Incapacitating Accidents	0.55	0.56	0.56	0.57	0.57	0.58	0.58	0.59	0.60	0.60	0.61	0.61	0.62	0.63	0.63	0.64	0.64	0.65	0.66	0.66

Cost Savings from Accidents Avoided (2015$ M)	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
VSL	$ 4.00	$ 4.09	$ 4.18	$ 4.27	$ 4.36	$ 4.46	$ 4.55	$ 4.65	$ 4.76	$ 4.86	$ 4.97	$ 5.07	$ 5.19	$ 5.30	$ 5.42	$ 5.53	$ 5.66	$ 5.78	$ 5.91	$ 6.04
MAIS 4	$ 1.50	$ 1.53	$ 1.57	$ 1.60	$ 1.64	$ 1.67	$ 1.71	$ 1.75	$ 1.78	$ 1.82	$ 1.86	$ 1.90	$ 1.95	$ 1.99	$ 2.03	$ 2.08	$ 2.12	$ 2.17	$ 2.22	$ 2.26
Total	**$ 5.50**	**$ 5.62**	**$ 5.74**	**$ 5.87**	**$ 6.00**	**$ 6.13**	**$ 6.26**	**$ 6.40**	**$ 6.54**	**$ 6.68**	**$ 6.83**	**$ 6.98**	**$ 7.13**	**$ 7.29**	**$ 7.45**	**$ 7.61**	**$ 7.78**	**$ 7.95**	**$ 8.12**	**$ 8.30**
Discounted at 3%	$ 4.89	$ 4.85	$ 4.81	$ 4.77	$ 4.73	$ 4.70	$ 4.66	$ 4.62	$ 4.59	$ 4.55	$ 4.51	$ 4.48	$ 4.44	$ 4.41	$ 4.37	$ 4.34	$ 4.31	$ 4.27	$ 4.24	$ 4.21
Discounted at 7%	$ 4.19	$ 4.01	$ 3.83	$ 3.65	$ 3.49	$ 3.33	$ 3.18	$ 3.04	$ 2.90	$ 2.77	$ 2.65	$ 2.53	$ 2.42	$ 2.31	$ 2.20	$ 2.10	$ 2.01	$ 1.92	$ 1.83	$ 1.75

Climbing Lane	Total
Total	$ 136.17
Discounted at 3%	$ 90.75
Discounted at 7%	$ 56.13

2 Reversible Lanes

Baseline Safety

2020	
Average Annual Fatal	1.27
Average Annual Incapacitating	1.27

Note: assume incapacitating are MAIS 4 (severe) injuries

Future Safety

2020	
Average Annual Fatal	0.79
Average Annual Incapacitating	0.83

Note: assume incapacitating are MAIS 4 (severe) injuries

Annual growth factor for incidents (thus a reduction in incidents avoided) 1%

	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
Reduced Fatal Accidents	0.48	0.49	0.49	0.50	0.50	0.51	0.51	0.52	0.52	0.53	0.53	0.54	0.55	0.55	0.56	0.56	0.57	0.57	0.58	0.58
Reduced Incapacitating Accidents	0.44	0.45	0.45	0.46	0.46	0.47	0.47	0.48	0.48	0.49	0.49	0.50	0.50	0.51	0.51	0.52	0.52	0.53	0.53	0.54

Cost Savings from Accidents Avoided (2014$ M)	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
VSL	$ 4.96	$ 5.07	$ 5.18	$ 5.30	$ 5.41	$ 5.53	$ 5.65	$ 5.78	$ 5.90	$ 6.03	$ 6.16	$ 6.30	$ 6.44	$ 6.58	$ 6.72	$ 6.87	$ 7.02	$ 7.17	$ 7.33	$ 7.49
MAIS 4	$ 1.21	$ 1.24	$ 1.26	$ 1.29	$ 1.32	$ 1.35	$ 1.38	$ 1.41	$ 1.44	$ 1.47	$ 1.50	$ 1.54	$ 1.57	$ 1.61	$ 1.64	$ 1.68	$ 1.71	$ 1.75	$ 1.79	$ 1.83
Total	**$ 6.17**	**$ 6.31**	**$ 6.45**	**$ 6.59**	**$ 6.73**	**$ 6.88**	**$ 7.03**	**$ 7.18**	**$ 7.34**	**$ 7.50**	**$ 7.67**	**$ 7.84**	**$ 8.01**	**$ 8.18**	**$ 8.36**	**$ 8.55**	**$ 8.73**	**$ 8.92**	**$ 9.12**	**$ 9.32**
Discounted at 3%	$ 5.48	$ 5.44	$ 5.40	$ 5.36	$ 5.31	$ 5.27	$ 5.23	$ 5.19	$ 5.15	$ 5.11	$ 5.07	$ 5.03	$ 4.99	$ 4.95	$ 4.91	$ 4.87	$ 4.84	$ 4.80	$ 4.76	$ 4.72
Discounted at 7%	$ 4.71	$ 4.50	$ 4.30	$ 4.10	$ 3.92	$ 3.74	$ 3.57	$ 3.41	$ 3.26	$ 3.11	$ 2.97	$ 2.84	$ 2.71	$ 2.59	$ 2.47	$ 2.36	$ 2.26	$ 2.16	$ 2.06	$ 1.97

2 Reversible Lanes	Total
Total	$ 152.89
Discounted at 3%	$ 101.89
Discounted at 7%	$ 63.02

Shoulder Running

Baseline Safety							Future Safety													
	2020							2020												
Average Annual Fatal	1.27						Average Annual Fatal	0.93												
Average Annual Incapacitating	1.27						Average Annual Incapacitating	0.93												
Note: assume incapacitating are MAIS 4 (severe) injuries																				
Annual growth factor for incidents (thus a reduction in incidents avoided)	1%																			
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
Reduced Fatal Accidents	0.35	0.35	0.35	0.36	0.36	0.37	0.37	0.37	0.38	0.38	0.38	0.39	0.39	0.40	0.40	0.40	0.41	0.41	0.42	0.42
Reduced Incapacitating Accidents	0.34	0.34	0.35	0.35	0.35	0.36	0.36	0.36	0.37	0.37	0.38	0.38	0.38	0.39	0.39	0.39	0.40	0.40	0.41	0.41

Cost Savings from Accidents Avoided (2014$ M)	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
VSL	$ 3.57	$ 3.65	$ 3.73	$ 3.81	$ 3.89	$ 3.98	$ 4.06	$ 4.15	$ 4.24	$ 4.34	$ 4.43	$ 4.53	$ 4.63	$ 4.73	$ 4.83	$ 4.94	$ 5.05	$ 5.16	$ 5.27	$ 5.39
MAIS 4	$ 0.93	$ 0.95	$ 0.97	$ 0.99	$ 1.01	$ 1.03	$ 1.06	$ 1.08	$ 1.10	$ 1.13	$ 1.15	$ 1.18	$ 1.20	$ 1.23	$ 1.26	$ 1.28	$ 1.31	$ 1.34	$ 1.37	$ 1.40
Total	**$ 4.49**	**$ 4.59**	**$ 4.69**	**$ 4.80**	**$ 4.90**	**$ 5.01**	**$ 5.12**	**$ 5.23**	**$ 5.35**	**$ 5.46**	**$ 5.58**	**$ 5.70**	**$ 5.83**	**$ 5.96**	**$ 6.09**	**$ 6.22**	**$ 6.36**	**$ 6.50**	**$ 6.64**	**$ 6.79**
Discounted at 3%	$ 3.99	$ 3.96	$ 3.93	$ 3.90	$ 3.87	$ 3.84	$ 3.81	$ 3.78	$ 3.75	$ 3.72	$ 3.69	$ 3.66	$ 3.63	$ 3.60	$ 3.58	$ 3.55	$ 3.52	$ 3.49	$ 3.47	$ 3.44
Discounted at 7%	$ 3.43	$ 3.27	$ 3.13	$ 2.99	$ 2.85	$ 2.72	$ 2.60	$ 2.49	$ 2.37	$ 2.27	$ 2.17	$ 2.07	$ 1.97	$ 1.89	$ 1.80	$ 1.72	$ 1.64	$ 1.57	$ 1.50	$ 1.43

Shoulder Running	Total
Total	$ 111.31
Discounted at 3%	$ 74.18
Discounted at 7%	$ 45.88

Travel Time Savings

Peak users save time due to average speed increases on the segment

I-17 Location 1 Black Canyon Hill

	Climbing Lane	2 Reversible Lanes	Shoulder Running
% Truck	13.0%	13.0%	13.0%
% Auto	87.0%	87.0%	87.0%

*Holds share constant across build and no build, and is equal for northbound and southbound

Trip Purpose	Business	Personal
Truck	100%	0%
Auto	0%	100%

Hourly Rates	$2013 Value of Time	$2015 Value of Time	
Truck	$ 25.80	$ 26.55	National Average
Auto	$ 17.50	$ 18.01	Personal Intercity Travel

Source: TIGER BENEFIT-COST ANALYSIS (BCA) RESOURCE GUIDE, 2015

http://www.transportation.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

Value of Time 1.20% Annual Increase

	2015	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Truck	$ 26.55	$ 28.18	$ 28.52	$ 28.86	$ 29.20	$ 29.55	$ 29.91	$ 30.27	$ 30.63	$ 31.00	$ 31.37	$ 31.75	$ 32.13	$ 32.51	$ 32.90	$ 33.30	$ 33.70	$ 34.10	$ 34.51	$ 34.93
Auto	$ 18.01	$ 19.11	$ 19.34	$ 19.57	$ 19.81	$ 20.05	$ 20.29	$ 20.53	$ 20.78	$ 21.03	$ 21.28	$ 21.53	$ 21.79	$ 22.05	$ 22.32	$ 22.59	$ 22.86	$ 23.13	$ 23.41	$ 23.69

Annualization factor	270
Avg Auto Occ Rate	1.55
Discount rates	3%
	7%
Discount Year	2016

I-17 Location 1 Black Canyon Hill

PEAK Traffic	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Climbing Lane																				
Northbound	372,688	381,388	390,087	398,787	407,487	416,186	424,886	433,586	442,285	450,985	459,685	468,384	477,084	485,783	494,483	503,183	508,215	513,297	518,430	523,614
Southbound	372,688	381,388	390,087	398,787	407,487	416,186	424,886	433,586	442,285	450,985	459,685	468,384	477,084	485,783	494,483	503,183	508,215	513,297	518,430	523,614
Note: Assume 1% growth rate	1% annual AADT growth after 2035																			
2 Reversible Lanes																				
Northbound	372,688	381,388	390,087	398,787	407,487	416,186	424,886	433,586	442,285	450,985	459,685	468,384	477,084	485,783	494,483	503,183	508,215	513,297	518,430	523,614
Southbound	372,688	381,388	390,087	398,787	407,487	416,186	424,886	433,586	442,285	450,985	459,685	468,384	477,084	485,783	494,483	503,183	508,215	513,297	518,430	523,614
Note: Assume 1% growth rate	1% annual AADT growth after 2035																			
Shoulder Running																				
Northbound	372,688	381,388	390,087	398,787	407,487	416,186	424,886	433,586	442,285	450,985	459,685	468,384	477,084	485,783	494,483	503,183	508,215	513,297	518,430	523,614
Southbound	372,688	381,388	390,087	398,787	407,487	416,186	424,886	433,586	442,285	450,985	459,685	468,384	477,084	485,783	494,483	503,183	508,215	513,297	518,430	523,614
Note: Assume 1% growth rate	1% annual AADT growth after 2035																			

Climbing Lane	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Truck																				
Northbound	$ 441	$ 457	$ 473	$ 489	$ 506	$ 523	$ 540	$ 558	$ 576	$ 594	$ 613	$ 632	$ 652	$ 671	$ 692	$ 712	$ 728	$ 744	$ 761	$ 777
Southbound	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Auto																				
Northbound	$ 3,104	$ 3,214	$ 3,327	$ 3,442	$ 3,559	$ 3,679	$ 3,801	$ 3,925	$ 4,052	$ 4,181	$ 4,313	$ 4,447	$ 4,584	$ 4,724	$ 4,866	$ 5,011	$ 5,122	$ 5,236	$ 5,351	$ 5,470
Southbound	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total	$ 3,545	$ 3,671	$ 3,800	$ 3,931	$ 4,065	$ 4,202	$ 4,341	$ 4,483	$ 4,628	$ 4,776	$ 4,926	$ 5,080	$ 5,236	$ 5,395	$ 5,558	$ 5,724	$ 5,850	$ 5,980	$ 6,112	$ 6,247
Discounted at 3%	$ 3,149	$ 3,167	$ 3,182	$ 3,196	$ 3,209	$ 3,220	$ 3,230	$ 3,239	$ 3,246	$ 3,252	$ 3,257	$ 3,260	$ 3,263	$ 3,264	$ 3,265	$ 3,264	$ 3,239	$ 3,214	$ 3,190	$ 3,165
Discounted at 7%	$ 2,704	$ 2,617	$ 2,532	$ 2,448	$ 2,366	$ 2,285	$ 2,207	$ 2,130	$ 2,055	$ 1,982	$ 1,910	$ 1,841	$ 1,774	$ 1,708	$ 1,644	$ 1,583	$ 1,512	$ 1,444	$ 1,380	$ 1,318

Climbing Lane	Total
Total, $M	$ 0.10
Discounted at 3%	$ 0.06
Discounted at 7%	$ 0.04

2 Reversible Lanes	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Truck																				
Northbound	$ 358	$ 370	$ 383	$ 397	$ 410	$ 424	$ 438	$ 452	$ 467	$ 482	$ 497	$ 512	$ 528	$ 544	$ 561	$ 577	$ 590	$ 603	$ 617	$ 630
Southbound	$ 358	$ 370	$ 383	$ 397	$ 410	$ 424	$ 438	$ 452	$ 467	$ 482	$ 497	$ 512	$ 528	$ 544	$ 561	$ 577	$ 590	$ 603	$ 617	$ 630
Auto																				
Northbound	$ 2,516	$ 2,606	$ 2,697	$ 2,790	$ 2,885	$ 2,982	$ 3,081	$ 3,182	$ 3,285	$ 3,390	$ 3,496	$ 3,605	$ 3,716	$ 3,829	$ 3,945	$ 4,062	$ 4,152	$ 4,244	$ 4,338	$ 4,434
Southbound	$ 2,516	$ 2,606	$ 2,697	$ 2,790	$ 2,885	$ 2,982	$ 3,081	$ 3,182	$ 3,285	$ 3,390	$ 3,496	$ 3,605	$ 3,716	$ 3,829	$ 3,945	$ 4,062	$ 4,152	$ 4,244	$ 4,338	$ 4,434
Total	$ 5,747	$ 5,952	$ 6,161	$ 6,374	$ 6,591	$ 6,812	$ 7,038	$ 7,268	$ 7,503	$ 7,743	$ 7,987	$ 8,235	$ 8,489	$ 8,748	$ 9,011	$ 9,280	$ 9,485	$ 9,695	$ 9,909	$ 10,128
Discounted at 3%	$ 5,106	$ 5,134	$ 5,159	$ 5,182	$ 5,203	$ 5,221	$ 5,237	$ 5,251	$ 5,263	$ 5,272	$ 5,280	$ 5,286	$ 5,290	$ 5,292	$ 5,293	$ 5,292	$ 5,252	$ 5,211	$ 5,171	$ 5,132
Discounted at 7%	$ 4,384	$ 4,243	$ 4,105	$ 3,969	$ 3,836	$ 3,705	$ 3,578	$ 3,453	$ 3,331	$ 3,213	$ 3,097	$ 2,985	$ 2,876	$ 2,769	$ 2,666	$ 2,566	$ 2,451	$ 2,341	$ 2,237	$ 2,137

2 Reversible Lanes	Total
Total, $M	$ 0.16
Discounted at 3%	$ 0.10
Discounted at 7%	$ 0.06

Shoulder Running	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Truck																				
Northbound	$ 441	$ 457	$ 473	$ 489	$ 506	$ 523	$ 540	$ 558	$ 576	$ 594	$ 613	$ 632	$ 652	$ 671	$ 692	$ 712	$ 728	$ 744	$ 761	$ 777
Southbound	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Auto																				
Northbound	$ 3,104	$ 3,214	$ 3,327	$ 3,442	$ 3,559	$ 3,679	$ 3,801	$ 3,925	$ 4,052	$ 4,181	$ 4,313	$ 4,447	$ 4,584	$ 4,724	$ 4,866	$ 5,011	$ 5,122	$ 5,236	$ 5,351	$ 5,470
Southbound	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total	$ 3,545	$ 3,671	$ 3,800	$ 3,931	$ 4,065	$ 4,202	$ 4,341	$ 4,483	$ 4,628	$ 4,776	$ 4,926	$ 5,080	$ 5,236	$ 5,395	$ 5,558	$ 5,724	$ 5,850	$ 5,980	$ 6,112	$ 6,247
Discounted at 3%	$ 3,149	$ 3,167	$ 3,182	$ 3,196	$ 3,209	$ 3,220	$ 3,230	$ 3,239	$ 3,246	$ 3,252	$ 3,257	$ 3,260	$ 3,263	$ 3,264	$ 3,265	$ 3,264	$ 3,239	$ 3,214	$ 3,190	$ 3,165
Discounted at 7%	$ 2,704	$ 2,617	$ 2,532	$ 2,448	$ 2,366	$ 2,285	$ 2,207	$ 2,130	$ 2,055	$ 1,982	$ 1,910	$ 1,841	$ 1,774	$ 1,708	$ 1,644	$ 1,583	$ 1,512	$ 1,444	$ 1,380	$ 1,318

Shoulder Running	Total
Total, $M	$ 0.10
Discounted at 3%	$ 0.06
Discounted at 7%	$ 0.04

Travel Time Savings due to Avoided Incidents

Users save time from more efficient incident management

I-17 Location 1: Black Canyon Hill

	Climbing Lane	2 Reversible Lanes	Shoulder Running
Total Hours Avoided per Year, 2035	54,000	286,000	53,000
% Truck	13.0%	13.0%	13.0%
% Auto	87.0%	87.0%	87.0%

*Holds share constant across build and no build, and is equal for northbound and southbound. See BlackCanyonHill tab.

Hourly Rates	$2013 Value of Time	$2015 Value of Time	
Truck	$ 25.80	$ 26.55	National Average
Auto	$ 17.50	$ 18.01	Personal Intercity Travel

Source: TIGER BENEFIT-COST ANALYSIS (BCA) RESOURCE GUIDE, 2015

http://www.transportation.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

Value of Time 1.20% Annual Increase

	2015	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Truck	$ 26.55	$ 28.18	$ 28.52	$ 28.86	$ 29.20	$ 29.55	$ 29.91	$ 30.27	$ 30.63	$ 31.00	$ 31.37	$ 31.75	$ 32.13	$ 32.51	$ 32.90	$ 33.30	$ 33.70	$ 34.10	$ 34.51	$ 34.93	$ 35.35
Auto	$ 18.01	$ 19.11	$ 19.34	$ 19.57	$ 19.81	$ 20.05	$ 20.29	$ 20.53	$ 20.78	$ 21.03	$ 21.28	$ 21.53	$ 21.79	$ 22.05	$ 22.32	$ 22.59	$ 22.86	$ 23.13	$ 23.41	$ 23.69	$ 23.97

Discount Rate	3%
	7%
Annualization Factor	270
Discount Year	2016
Auto Occ Rate	1.55
Annual growth factor for incidents (thus a reduction in incidents avoided)	1.0%

I-17 Location 1: Black Canyon Hill

Hours Avoided per Year: Location 1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Climbing Lane	39,996	40,929	41,863	42,797	43,730	44,664	45,597	46,531	47,465	48,398	49,332	50,266	51,199	52,133	53,066	54,000	54,540	55,085	55,636	56,193
2RLs	211,829	216,774	221,719	226,663	231,608	236,553	241,497	246,442	251,387	256,332	261,276	266,221	271,166	276,111	281,055	286,000	288,860	291,749	294,666	297,613
Shoulder Running	39,255	40,171	41,088	42,004	42,920	43,837	44,753	45,669	46,586	47,502	48,418	49,335	50,251	51,167	52,084	53,000	53,530	54,065	54,606	55,152

Climbing Lane

Value of Time	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Truck	$ 146,509	$ 151,728	$ 157,052	$ 162,481	$ 168,018	$ 173,664	$ 179,422	$ 185,293	$ 191,279	$ 197,381	$ 203,603	$ 209,946	$ 216,412	$ 223,002	$ 229,720	$ 236,567	$ 241,799	$ 247,148	$ 252,615	$ 258,203
Auto	$ 1,030,840	$ 1,067,561	$ 1,105,016	$ 1,143,216	$ 1,182,173	$ 1,221,901	$ 1,262,412	$ 1,303,720	$ 1,345,837	$ 1,388,777	$ 1,432,553	$ 1,477,181	$ 1,522,673	$ 1,569,044	$ 1,616,309	$ 1,664,483	$ 1,701,301	$ 1,738,934	$ 1,777,399	$ 1,816,715
Total	$ 1,177,349	$ 1,067,561	$ 1,105,016	$ 1,143,216	$ 1,182,173	$ 1,221,901	$ 1,262,412	$ 1,303,720	$ 1,345,837	$ 1,388,777	$ 1,432,553	$ 1,477,181	$ 1,522,673	$ 1,569,044	$ 1,616,309	$ 1,664,483	$ 1,701,301	$ 1,738,934	$ 1,777,399	$ 1,816,715
Discounted at 3%	$ 1,046,059	$ 920,888	$ 925,434	$ 929,539	$ 933,219	$ 936,485	$ 939,353	$ 941,835	$ 943,943	$ 945,689	$ 947,087	$ 948,146	$ 948,879	$ 949,298	$ 949,411	$ 949,231	$ 941,969	$ 934,763	$ 927,611	$ 920,515
Discounted at 7%	$ 898,194	$ 761,157	$ 736,319	$ 711,937	$ 688,036	$ 664,633	$ 641,746	$ 619,388	$ 597,568	$ 576,293	$ 555,569	$ 535,398	$ 515,782	$ 496,719	$ 478,208	$ 460,243	$ 439,649	$ 419,975	$ 401,182	$ 383,230

Climbing Lane	Total
Total, $M	$ 28.51
Discounted at 3%	$ 18.88
Discounted at 7%	$ 11.58

2 Reversibsle Lanes

Value of Time	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Truck	$ 775,957	$ 803,599	$ 831,792	$ 860,547	$ 889,872	$ 919,777	$ 950,271	$ 981,365	$ 1,013,068	$ 1,045,391	$ 1,078,344	$ 1,111,937	$ 1,146,180	$ 1,181,086	$ 1,216,664	$ 1,252,927	$ 1,280,641	$ 1,308,969	$ 1,337,923	$ 1,367,518
Auto	$ 5,459,633	$ 5,654,122	$ 5,852,493	$ 6,054,810	$ 6,261,140	$ 6,471,551	$ 6,686,109	$ 6,904,885	$ 7,127,949	$ 7,355,372	$ 7,587,227	$ 7,823,587	$ 8,064,528	$ 8,310,124	$ 8,560,453	$ 8,815,594	$ 9,010,594	$ 9,209,909	$ 9,413,632	$ 9,621,862
Total	$ 6,235,589	$ 6,457,721	$ 6,684,285	$ 6,915,357	$ 7,151,012	$ 7,391,327	$ 7,636,380	$ 7,886,250	$ 8,141,017	$ 8,400,763	$ 8,665,571	$ 8,935,524	$ 9,210,708	$ 9,491,210	$ 9,777,117	$ 10,068,520	$ 10,291,236	$ 10,518,878	$ 10,751,555	$ 10,989,380
Discounted at 3%	$ 5,540,240	$ 5,570,486	$ 5,597,983	$ 5,622,818	$ 5,645,075	$ 5,664,837	$ 5,682,184	$ 5,697,195	$ 5,709,946	$ 5,720,511	$ 5,728,963	$ 5,735,373	$ 5,739,809	$ 5,742,338	$ 5,743,026	$ 5,741,936	$ 5,698,008	$ 5,654,415	$ 5,611,156	$ 5,568,228
Discounted at 7%	$ 4,757,101	$ 4,604,266	$ 4,454,021	$ 4,306,537	$ 4,161,954	$ 4,020,392	$ 3,881,948	$ 3,746,701	$ 3,614,709	$ 3,486,018	$ 3,360,658	$ 3,238,645	$ 3,119,985	$ 3,004,674	$ 2,892,696	$ 2,784,030	$ 2,659,451	$ 2,540,447	$ 2,426,768	$ 2,318,175

2 Reversible Lanes	Total
Total, $M	$ 171.60
Discounted at 3%	$ 113.41
Discounted at 7%	$ 69.38

Shoulder Running

Value of Time	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Truck	$ 143,796	$ 148,919	$ 154,143	$ 159,472	$ 164,906	$ 170,448	$ 176,099	$ 181,861	$ 187,736	$ 193,726	$ 199,833	$ 206,058	$ 212,404	$ 218,873	$ 225,466	$ 232,186	$ 237,322	$ 242,571	$ 247,937	$ 253,421
Auto	$ 1,011,750	$ 1,047,792	$ 1,084,553	$ 1,122,045	$ 1,160,281	$ 1,199,273	$ 1,239,034	$ 1,279,577	$ 1,320,914	$ 1,363,058	$ 1,406,025	$ 1,449,826	$ 1,494,475	$ 1,539,988	$ 1,586,378	$ 1,633,659	$ 1,669,795	$ 1,706,731	$ 1,744,484	$ 1,783,072
Total	$ 1,011,750	$ 1,047,792	$ 1,084,553	$ 1,122,045	$ 1,160,281	$ 1,199,273	$ 1,239,034	$ 1,279,577	$ 1,320,914	$ 1,363,058	$ 1,406,025	$ 1,449,826	$ 1,494,475	$ 1,539,988	$ 1,586,378	$ 1,633,659	$ 1,669,795	$ 1,706,731	$ 1,744,484	$ 1,783,072
Discounted at 3%	$ 898,927	$ 903,834	$ 908,296	$ 912,325	$ 915,937	$ 919,143	$ 921,958	$ 924,393	$ 926,462	$ 928,177	$ 929,548	$ 930,588	$ 931,308	$ 931,718	$ 931,830	$ 931,653	$ 924,525	$ 917,452	$ 910,433	$ 903,468
Discounted at 7%	$ 771,859	$ 747,061	$ 722,683	$ 698,753	$ 675,294	$ 652,325	$ 629,862	$ 607,918	$ 586,501	$ 565,621	$ 545,281	$ 525,484	$ 506,231	$ 487,521	$ 469,352	$ 451,720	$ 431,507	$ 412,198	$ 393,753	$ 376,134

Shoulder Running	Total
Total, $M	$ 27.84
Discounted at 3%	$ 18.40
Discounted at 7%	$ 11.26

Emissions

Reduction in idling for incidents reduces emissions

Emissions Factors (g/hr) for Automobiles

	CO	NOX	PM2.5	PM10	SO2	VOC	CO2	THC
LDGV	71.225	3.515				2.683	8887	3.163

Source: EPA 2008, Table 1 — * grams of CO2 per gallon; 1 hour = 1 gallon

Accessed at: http://www.epa.gov/otaq/consumer/420f08025.pd — http://www.epa.gov/fueleconomy/fetrends/1975-2014/420r14023a.pdf

Emissions Factors (g/hr) for Trucks

	CO	NOX	PM2.5	PM10	SO2	VOC	CO2	THC
Heavy Duty Diesel, VIIIb	34.473	42.345	1.114	1.211		4.218	10180	4.27

Source: EPA 2008, Table 2 — * grams of CO2 per gallon; 1 hour = 1 gallon idling

Accessed at: http://www.epa.gov/otaq/consumer/420f08025.pd — http://www.epa.gov/fueleconomy/fetrends/1975-2014/420r14023a.pdf

http://www.epa.gov/region1/eco/diesel/pdfs/Diesel_Factsheet_Truck_Idling.pdf

I-17 Location 1 Inputs

Annual Peak Hours of Idling Reduced for Incidents	**Hours, 2035**				
Climbing Lane	54,000		Hours distributed by Vehicle Type		
2 Reversible Lanes	286,000		% Truck	13.0%	Annualization Factor 270
			% Auto	87.0%	
Shoulder Running	53,000		Note: Held constant throughout analysis period		
Note: Held constant throughout analysis period					

Annual Peak Hours of Idling Reduced	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
Climbing Lane	39,996	40,929	41,863	42,797	43,730	44,664	45,597	46,531	47,465	48,398	49,332	50,266	51,199	52,133	53,066	54,000	54,540	55,085	55,636	56,193
2 Reversible Lanes	211,829	216,774	221,719	226,663	231,608	236,553	241,497	246,442	251,387	256,332	261,276	266,221	271,166	276,111	281,055	286,000	288,860	291,749	294,666	297,613
Shoulder Running	39,255	40,171	41,088	42,004	42,920	43,837	44,753	45,669	46,586	47,502	48,418	49,335	50,251	51,167	52,084	53,000	53,530	54,065	54,606	55,152

Annual Truck Hours of Idling Reduced	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
Climbing Lane	5,199	5,321	5,442	5,564	5,685	5,806	5,928	6,049	6,170	6,292	6,413	6,535	6,656	6,777	6,899	7,020	7,090	7,161	7,233	7,305
2 Reversible Lanes	27,538	28,181	28,823	29,466	30,109	30,752	31,395	32,037	32,680	33,323	33,966	34,609	35,252	35,894	36,537	37,180	37,552	37,927	38,307	38,690
Shoulder Running	5,103	5,222	5,341	5,461	5,580	5,699	5,818	5,937	6,056	6,175	6,294	6,414	6,533	6,652	6,771	6,890	6,959	7,028	7,099	7,170

Annual Auto Hours of Idling Reduced	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
Climbing Lane	34,796	35,609	36,421	37,233	38,045	38,858	39,670	40,482	41,294	42,107	42,919	43,731	44,543	45,356	46,168	46,980	47,450	47,924	48,404	48,888
2 Reversible Lanes	184,291	188,593	192,895	197,197	201,499	205,801	210,103	214,405	218,707	223,009	227,310	231,612	235,914	240,216	244,518	248,820	251,308	253,821	256,359	258,923
Shoulder Running	34,152	34,949	35,746	36,544	37,341	38,138	38,935	39,732	40,530	41,327	42,124	42,921	43,718	44,516	45,313	46,110	46,571	47,037	47,507	47,982

Only looking at vehicles, don't need to factor in occ rate

Annual Emission Avoided (tons)

907185 grams per short ton

1000000 grams per metric ton — 2,767,626

Climbing Lane	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
CO	2.93	3.00	3.07	3.13	3.20	3.27	3.34	3.41	3.48	3.54	3.61	3.68	3.75	3.82	3.89	3.96	3.99	4.03	4.08	4.12
NOX	0.38	0.39	0.40	0.40	0.41	0.42	0.43	0.44	0.45	0.46	0.47	0.47	0.48	0.49	0.50	0.51	0.51	0.52	0.53	0.53
PM2.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
PM10	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
SO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VOC	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.18	0.18	0.18
CO2	362.16	370.62	379.07	387.53	395.98	404.43	412.89	421.34	429.80	438.25	446.70	455.16	463.61	472.07	480.52	488.97	493.86	498.80	503.79	508.83
THC	0.15	0.15	0.15	0.16	0.16	0.16	0.17	0.17	0.17	0.18	0.18	0.18	0.19	0.19	0.19	0.20	0.20	0.20	0.20	0.20

All emissions are shown in short tons except for CO2, which is in metric tons

2 Reversible Lanes	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
CO	15.52	15.88	16.24	16.60	16.96	17.33	17.69	18.05	18.41	18.78	19.14	19.50	19.86	20.22	20.59	20.95	21.16	21.37	21.58	21.80
NOX	2.00	2.05	2.09	2.14	2.19	2.23	2.28	2.33	2.37	2.42	2.47	2.51	2.56	2.61	2.65	2.70	2.73	2.75	2.78	2.81
PM2.5	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05
PM10	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
SO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VOC	0.67	0.69	0.70	0.72	0.74	0.75	0.77	0.78	0.80	0.81	0.83	0.85	0.86	0.88	0.89	0.91	0.92	0.93	0.94	0.95
CO2	1,918.13	1,962.91	2,007.68	2,052.46	2,097.23	2,142.01	2,186.78	2,231.56	2,276.33	2,321.11	2,365.88	2,410.66	2,455.43	2,500.21	2,544.98	2,589.76	2,615.65	2,641.81	2,668.23	2,694.91
THC	0.77	0.79	0.81	0.83	0.84	0.86	0.88	0.90	0.92	0.93	0.95	0.97	0.99	1.01	1.02	1.04	1.05	1.06	1.07	1.08

All emissions are shown in short tons except for CO2, which is in metric tons

Shoulder Running	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
CO	2.88	2.94	3.01	3.08	3.14	3.21	3.28	3.35	3.41	3.48	3.55	3.61	3.68	3.75	3.81	3.88	3.92	3.96	4.00	4.04
NOX	0.37	0.38	0.39	0.40	0.41	0.41	0.42	0.43	0.44	0.45	0.46	0.47	0.47	0.48	0.49	0.50	0.51	0.51	0.52	0.52
PM2.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
PM10	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
SO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VOC	0.12	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.17	0.18
CO2	355.46	363.76	372.05	380.35	388.65	396.95	405.24	413.54	421.84	430.14	438.43	446.73	455.03	463.32	471.62	479.92	484.72	489.57	494.46	499.41
THC	0.14	0.15	0.15	0.15	0.16	0.16	0.16	0.17	0.17	0.17	0.18	0.18	0.18	0.19	0.19	0.19	0.20	0.20	0.20	0.20

All emissions are shown in short tons except for CO2, which is in metric tons

I-17 Location 1 Outputs

Climbing Lane

Annual Emissions Benefit (2015$ M)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
CO	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NOX	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
PM	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01
SO2	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
VOC	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
THC	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Total	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**
Discounted at 3%	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01
Discounted at 7%	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
CO2	**$ 0.02**	**$ 0.02**	**$ 0.02**	**$ 0.02**	**$ 0.02**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.04**	**$ 0.04**	**$ 0.04**	**$ 0.04**	**$ 0.04**
Discounted @ 3%	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02
Note:	Only discounted at 3% per Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon, February 2010																			

Emissions 20-year Total	**20-year Total**
Millions of 2015$	$0.19
Discounted at 3%	$0.13
Discounted at 7%	$0.08

CO2	**20-year Total**
Millions of 2015$	$0.60
Discounted at 3%	$0.39

2 Reversible Lanes

Annual Emissions Benefit (2015$ M)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
CO	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NOX	$ 0.01	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02
PM	$ 0.02	$ 0.02	$ 0.02	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03
SO2	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
VOC	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
THC	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Total	**$ 0.04**	**$ 0.04**	**$ 0.04**	**$ 0.04**	**$ 0.05**	**$ 0.05**	**$ 0.05**	**$ 0.05**	**$ 0.05**	**$ 0.05**	**$ 0.05**	**$ 0.05**	**$ 0.05**	**$ 0.05**	**$ 0.05**	**$ 0.06**	**$ 0.06**	**$ 0.06**	**$ 0.06**	**$ 0.06**
Discounted at 3%	$ 0.04	$ 0.04	$ 0.04	$ 0.04	$ 0.04	$ 0.04	$ 0.04	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03
Discounted at 7%	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.01	$ 0.01	$ 0.01	$ 0.01
CO2	**$ 0.11**	**$ 0.11**	**$ 0.12**	**$ 0.12**	**$ 0.13**	**$ 0.13**	**$ 0.14**	**$ 0.15**	**$ 0.15**	**$ 0.16**	**$ 0.16**	**$ 0.16**	**$ 0.17**	**$ 0.18**	**$ 0.18**	**$ 0.19**	**$ 0.20**	**$ 0.20**	**$ 0.21**	**$ 0.21**
Discounted @ 3%	$ 0.10	$ 0.10	$ 0.10	$ 0.10	$ 0.10	$ 0.10	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.11	$ 0.11	$ 0.11	$ 0.11	$ 0.11	$ 0.11	$ 0.11	$ 0.11	$ 0.11	$ 0.11
Note:	Only discounted at 3% per Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon, February 2010																			

Emissions 20-year Total	**20-year Total**
Millions of 2015$	$1.00
Discounted at 3%	$0.67
Discounted at 7%	$0.42

CO2	**20-year Total**
Millions of 2015$	$3.18
Discounted at 3%	$2.09

Shoulder Running																					
Annual Emissions Benefit (2015$ M)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
CO	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NOX	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
PM	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01
SO2	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
VOC	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
THC	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Total	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**	**$ 0.01**
Discounted at 3%	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01
Discounted at 7%	$ 0.01	$ 0.01	$ 0.01	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
CO2	**$ 0.02**	**$ 0.02**	**$ 0.02**	**$ 0.02**	**$ 0.02**	**$ 0.02**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.03**	**$ 0.04**	**$ 0.04**	**$ 0.04**	**$ 0.04**	**$ 0.04**
Discounted @ 3%	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02
Note:	Only discounted at 3% per Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon, February 2010																			

Emissions 20-year Total	**20-year Total**
Millions of 2015$	$0.19
Discounted at 3%	$0.13
Discounted at 7%	$0.08

CO2	**20-year Total**
Millions of 2015$	$0.59
Discounted at 3%	$0.38

Appendix C

Crash Modification Factors

Appendix C Crash Modification Factors

SOLUTION	CONST COST	UNIT	FACTOR	TOTAL CONST COST	DESCRIPTION	CMF for Corridor Profile Studies	CMF Notes
REHABILITATION							
Rehabilitate Pavement (AC)	$270,000	Mile	2.20	$590,000	Mill and replace 1"-3" AC pvmt; accounts for 38' width; for one direction of travel on two lane roadway; includes pavement, striping, RPMs, rumble strips	0.71	Avg of 3 values from clearinghouse; include striping, RPMs etc. 0.92 x 0.77 = 0.71
Rehabilitate Bridge	$65	SF	2.20	$140	Based on deck area; bridge only - no other costs included	0.95	Assumed - should have a minor effect on crashes at the bridge
GEOMETRIC IMPROVEMENT							
Re-profile Roadway	$968,000	Mile	2.20	$2,130,000	Includes excavation of approximately 3", pavement replacement (AC), striping, RPMs, rumble strips, for one direction of travel of 2-lane roadway (38' width)	0.80	Assumed - this is similar (but slightly conservative) to rehab pavement. This solution is intended to address vertical clearance at bridge, not profile issue.
Realign Roadway	$2,960,000	Mile	2.20	$6,510,000	All costs per direction except bridges; applicable to areas with small or moderate fills and cuts, minimal retaining walls	0.50	Based on CalTrans and NC DOT
Improve Skid Resistance	$668,500	Mile	2.20	$1,470,000	Average cost of pvmt replacement and variable depth paving to increase super-elevation; for one direction of travel on two lane roadway; includes pavement, striping, RPMs, rumble strips	0.67	Avg of 5 values from clearinghouse (0.77) and calculated value from HSM (0.87), times 0.77 to account for striping, RPMs, etc.
INFRASTRUCTURE IMPROVEMENT							
Construct Auxiliary Lanes (AC)	$914,000	Mile	2.20	$2,011,000	For addition of aux lane (AC) in one direction of travel; includes all costs except bridges; for generally at-grade facility with minimal walls and no major drainage improvements	0.78	Average of 4 values from clearinghouse
Construct Climbing Lane (High)	$3,000,000	Mile	2.20	$6,600,000	All costs except bridges; applicable to areas with large fills and cuts, retaining walls, rock blasting, steep slopes on both sides of road	0.75	From HSM
Construct Climbing Lane (Medium)	$2,250,000	Mile	2.20	$4,950,000	All costs except bridges; applicable to areas with medium or large fills and cuts, retaining walls, rock blasting, steep slopes on one side of road	0.75	From HSM
Construct Climbing Lane (Low)	$1,500,000	Mile	2.20	$3,300,000	All costs except bridges; applicable to areas with small or moderate fills and cuts, minimal retaining walls	0.75	From HSM
Construct Reversible Lane (Low)	$2,400,000	Lane-Mile	2.20	$5,280,000	All costs except bridges; applicable to areas with small or moderate fills and cuts, minimal retaining walls	0.70 for uphill and 0.85 for downhill	Based on proposed conditions on I-17 with 2 reversible lanes and a conc barrier
Construct Reversible Lane (High)	$4,800,000	Lane-Mile	2.20	$10,560,000	All costs except bridges; applicable to areas with large fills and cuts, retaining walls, rock blasting, mountainous terrain	0.70 for uphill and 0.85 for downhill	Based on proposed conditions on I-17 with 2 reversible lanes and a conc barrier
Construct Entry/Exit Ramp	$730,000	Each	2.20	$1,610,000	Cost per ramp; includes pavement, striping, signing, RPMs, lighting, typical earthwork & drainage; does not include any major structures or improvements on crossroad	1.09	Average of 16 values on clearinghouse; for adding a ramp not reconstructing
Modify Entry/Exit Ramp	$445,000	Each	2.20	$979,000	Cost per ramp; includes pavement, striping, signing, RPMs, lighting, minor earthwork, & drainage; For converting existing ramp to parallel-type configuration	0.21	Average of 4 values from clearinghouse (for exit ramps) and equation from HSM (for entrance ramp)
Widen & Modify Entry/Exit Ramp	$619,000	Each	2.20	$1,361,800	Cost per ramp; includes pavement, striping, signing, RPMs, lighting, minor earthwork, & drainage; For converting 1-lane ramp to 2-lane ramp and converting to parallel-type ramp	0.21	Will be same as "Modify Ramp"

SOLUTION	CONST COST	UNIT	FACTOR	TOTAL CONST COST	DESCRIPTION	CMF for Corridor Profile Studies	CMF Notes
Replace Pavement (AC)(with overexcavation)	$1,440,000	Mile	2.20	$3,170,000	Accounts for 38' width; for one direction of travel on two lane roadway; includes pavement, over excavation, striping, RPMs, rumble strips	0.71	Same as rehab
Replace Pavement (PCCP)(with overexcavation)	$1,730,000	Mile	2.20	$3,810,000	Accounts for 38' width; for one direction of travel on two lane roadway; includes pavement, over excavation, striping, RPMs, rumble strips	0.71	Same as rehab
Replace Bridge	$125	SF	2.20	$280	Based on deck area; bridge only - no other costs included	0.95	Assumed - should have a minor effect on crashes at the bridge
Widen Bridge	$175	SF	2.20	$390	Based on deck area; bridge only - no other costs included	0.90	Assumed - should have a minor effect on crashes at the bridge
Install Pedestrian Bridge	$135	SF	2.20	$300	Includes cost to construct bridge based on linear feet of the bridge. This costs includes and assumes ramps and sidewalks leading to the structure.		
Implement Automated Bridge De-icing	$115	SF	2.20	$250	Includes cost to replace bridge deck and install system	0.72 (snow/ice)	Average of 3 values on clearinghouse for snow/ice
OPERATIONAL IMPROVEMENT							
Implement Variable Speed Limits (Wireless, Overhead)	$718,900	Mile	2.20	$1,580,000	Includes 2 signs per mile (foundations and structures), wireless communication, detectors	0.92	From 1 value from clearinghouse
Implement Variable Speed Limits (Wireless, Ground-mount)	$169,700	Mile	2.20	$373,300	Includes 2 signs per mile (foundations and posts), wireless communication, detectors	0.92	From 1 value from clearinghouse
Implement Variable Speed Limits (Wireless, Solar, Overhead)	$502,300	Mile	2.20	$1,110,000	Includes 2 signs per mile (foundations and structures), wireless communication, detectors, solar power	0.92	From 1 value from clearinghouse
Implement Variable Speed Limits (Wireless, Solar, Ground-mount)	$88,400	Mile	2.20	$194,500	Includes 2 signs per mile (foundations and posts), wireless communication, detectors, solar power	0.92	From 1 value from clearinghouse
Implement Ramp Metering (Low)	$25,000	Each	2.20	$55,000	For each entry ramp location; urban area with existing ITS backbone infrastructure; includes signals, poles, timer, pull boxes, etc	0.64	From 1 value from clearinghouse
Implement Ramp Metering (High)	$150,000	Mile	2.20	$330,000	Area without existing ITS backbone infrastructure; in addition to ramp meters, also includes conduit, fiber optic lines, and power	0.64	From 1 value from clearinghouse
Implement Shoulder Running (ATM components only)	$718,900	Mile	2.20	$1,581,600	Includes overhead signs, wireless communication, etc, but does not include shoulder widening	0.78	Combination of adding climbing lane & reducing shldr when active, and increasing shldr when not active
Implement Shoulder Running (ATM and shoulder widening)	$1,920,000	Mile	2.20	$4,224,000	Includes overhead signs, communication backbone, etc, and shoulder widening with pavement striping, striping, etc to widen by 10'	0.78	Combination of adding climbing lane & reducing shldr when active, and increasing shldr when not active
Implement Shoulder Running (ATM and shoulder widening in mountainous terrain)	$3,120,000	Mile	2.20	$6,864,000	Includes overhead signs, communication backbone, etc, and shoulder widening in mountainous terrain with pavement striping, striping, etc to widen by 10'	0.78	Combination of adding climbing lane & reducing shldr when active, and increasing shldr when not active
ROADSIDE DESIGN							
Install Guardrail	$130,000	Mile	2.20	$286,000	One side of road	0.62 (ROR)	0.62 is avg of 2 values from clearinghouse
Install Cable Barrier	$80,000	Mile	2.20	$176,000		0.81	0.81 is average of 5 values from clearinghouse
Widen Shoulder (AC)	$249,000	Mile	2.20	$548,000	Includes widening by a total of 4'; new pavement for 4' width and mill and replace existing 10' width; includes pavement, minor earthwork, striping edge lines, RPMs, and rumble strips	0.86 (1-4ft) 0.76 (4+ft)	0.86 is avg of 5 values from clearing house. 0.76 is calculated from HSM for >4 ft.
Rehabilitate Shoulder (AC)	$105,000	Mile	2.20	$231,000	One direction of travel (14' total shldr width); includes paving (mill and replace), rumble strips, RPMs, and striping of both shoulders	0.75	0.98 is average of 34 values on clearinghouse for shldr rehab/replace; include striping, etc; = 0.98*0.77=0.75

SOLUTION	CONST COST	UNIT	FACTOR	TOTAL CONST COST	DESCRIPTION	CMF for Corridor Profile Studies	CMF Notes
Replace Shoulder (AC)	$357,000	Mile	2.20	$785,000	Accounts for 14' width; for one direction of travel; includes pavement, rumble strips, striping, RPMs	0.75	0.98 is average of 34 values on clearinghouse for shldr rehab/replace; include striping, etc; = 0.98*0.77=0.75
Install Rumble Strip	$5,500	Mile	2.20	$12,000	Both edges - one direction of travel; includes only rumble strip; no shoulder rehab or paving or striping	0.89	Average of 75 values on clearinghouse and consistent with HSM
Install Safety Edge	$80,000	Mile	2.20	$176,000		0.87	Average of 12 values on clearinghouse
Install Access Barrier Fence	$15	LF	2.20	$33	8' fencing along residential section of roadway	0.1 (ped only)	Equal to ped overpass
Remove Tree/Vegetation	$200,000	Mile	2.20	$440,000		0.72 (snow/ice)	Average of 3 values on clearinghouse for snow/ice
ROADWAY DELINEATION							
Install High-Visibility Edge Line Striping	$10,800	Mile	2.20	$23,800	2 edge lines and lane line - one direction of travel	0.77	Avg of 3 values from clearinghouse. Assumes package of striping, delineators, and RPMs
Install High-Visibility Delineators	$6,500	Mile	2.20	$14,300	Both edges - one direction of travel	0.77	Avg of 3 values from clearinghouse. Assumes package of striping, delineators, and RPMs
Install Raised Pavement Markers	$2,000	Mile	2.20	$4,400	Both edges - one direction of travel	0.77	Avg of 3 values from clearinghouse. Assumes package of striping, delineators, and RPMs
IMPROVED VISIBILITY							
Cut Side Slopes	$80	Lin Ft	2.20	$200	For small grading to correct sight distance issues; not major grading	0.85	Intent of this solution is to improve sight distance. Most CMF's are associated with vehicles traveling on slope. Recommended CMF is based on FDOT and NCDOT but is more conservative.
Install Lighting (connect to existing power)	$270,000	Mile	2.20	$594,000	One side of road only; offset lighting, not high-mast; does not include power supply; includes poles, luminaire, pull boxes, conduit, conductor	0.75 (night)	Average of 3 values on clearinghouse & consistent with HSM
Install Lighting (solar powered LED)	$10,000	Pole	2.20	$22,000	Offset lighting, not high-mast; solar power LED; includes poles, luminaire, solar panel	0.75 (night)	Average of 3 values on clearinghouse & consistent with HSM
DRIVER INFORMATION/WARNING							
Install Dynamic Message Sign (DMS)	$250,000	Each	2.20	$550,000	Includes sign, overhead structure, and foundations; wireless communication; does not include power supply	1.00	Not expected to reduce crashes
Install Dynamic Weather Warning Beacons	$40,000	Each	2.20	$88,000	Assumes solar operation and wireless communication or connection to existing power and communication; ground mounted; includes posts, foundations, solar panel, and dynamic sign	0.65 (weather related)	Avg of 3 values from HSM for dynamic/changeable warning signs
Install Speed Feedback Signs	$25,000	Each	2.20	$55,000	Assumes solar operation and no communication; ground mounted; includes regulatory sign, posts, foundations, solar panel, and dynamic sign	0.54	From HSM
Install Chevrons	$18,400	Mile	2.20	$40,500	On one side of road - includes signs, posts, and foundations	0.79	Average of 11 values on clearinghouse
Install Warning Signs	$2,500	Each	2.20	$5,500	Includes 2 signs, posts, and foundations	0.83	Average of 4 clearinghouse values
DATA COLLECTION							
Install Roadside Weather Information System (RWIS)	$60,000	Each	2.20	$132,000	Assumes wireless communication and solar power, or connection to existing power and communications	1.00	Not expected to reduce crashes
Install Closed Circuit Television (CCTV) Camera	$25,000	Each	2.20	$55,000	Assumes connection to existing ITS backbone or wireless communication; does not include fiber-optic backbone infrastructure; includes pole, camera, etc	1.00	Not expected to reduce crashes

SOLUTION	CONST COST	UNIT	FACTOR	TOTAL CONST COST	DESCRIPTION	CMF for Corridor Profile Studies	CMF Notes
Install Vehicle Detection Stations	$15,000	Each	2.20	$33,000	Assumes wireless communication and solar power, or connection to existing power and communications	1.00	Not expected to reduce crashes
WIDEN CORRIDOR							
Construct New General Purpose Lane (PCCP)	$1,740,000	Mile	2.20	$3,830,000	For addition of 1 GP lane (PCCP) in one direction; includes all costs except bridges; for generally at-grade facility with minimal walls and no major drainage improvements	0.90	North Carolina DOT uses 0.90 and Florida DOT uses 0.87
Construct New General Purpose Lane (AC)	$1,200,000	Mile	2.20	$2,640,000	For addition of 1 GP lane (AC) in one direction; includes all costs except bridges; for generally at-grade facility with minimal walls and no major drainage improvements	0.90	North Carolina DOT uses 0.90 and Florida DOT uses 0.88
ALTERNATE ROUTE							
Construct Frontage Roads	$2,400,000	Mile	2.20	$5,280,000	For 2-lane AC frontage road; includes all costs except bridges; for generally at-grade facility with minimal walls	0.90	Assumed - similar to new general purpose lane

Appendix D

Performance Area Risk Factors

Appendix D Performance Area Risk Factors

Pavement Performance Area

- Mainline Daily Traffic Volume
- Mainline Daily Truck Volume
- Elevation
- Interrupted Flow

Elevation

Variance above 4000' divided by 1000; (Elev-4000)/1000

Score	Condition
0	< 4000’
0-5	4000’- 9000’
5	> 9000’

Mainline Daily Traffic Volume

Exponential equation; score = 5-(5*e$^{(ADT*-0.000039)}$)

Score	Condition
0	< 6,000
0-5	6,000 – 160,000
5	>160,000

Mainline Daily Truck Volume

Exponential equation; score = 5-(5*e$^{(ADT*-0.00025)}$)

Score	Condition
0	<900
0-5	900-25,000
5	>25,000

Interrupted Flow

Score	Condition
0	Not interrupted flow
5	Interrupted Flow

Bridge Performance Area

- Mainline Daily Traffic Volume
- Detour Length
- Elevation
- Scour Critical Rating
- Carries Mainline Traffic
- Vertical Clearance

Mainline Daily Traffic Volume

Exponential equation; score = 5-(5*e$^{(ADT*-0.000039)}$)

Score	Condition
0	<6,0000
0-5	6,000-160,000
5	>160,000

Elevation

Variance above 4000' divided by 1000; (Elev-4000)/1000

Score	Condition
0	< 4000’
0-5	4000’- 9000’
5 >	9000’

Carries Mainline

Score	Condition
0	Does not carry mainline traffic
5	Carries mainline traffic

Detour Scale

Divides detour length by 10 and multiplies by 2.5

Score	Condition
0	0 miles
0-5	0-20 miles
5	> 20 miles

Scour

Variance below 8

Score	Condition
0	Rating > 8
0-5	Rating 8 - 3
5	Rating < 3

Vertical Clearance

Variance below 16’ x 2.5; (16 –Clearance) x 2.5

Score	Condition
0	>16’
0-5	16’-14’
5	<14’

Mobility Performance Area

- Mainline VMT
- Detour Length
- Buffer Index (PTI-TTI)

Mainline VMT

Exponential equation; score = 5-(5*e$^{(ADT*-0.0000139)}$)

Score	Condition
0	<16,000
0-5	16,000-400,000
5	>400,000

Buffer Index

Buffer Index x 10

Score	Condition
0	Buffer Index = 0.00
0-5	Buffer Index 0.00-0.50
5	Buffer Index > 0.50

Detour Length

Score	Condition
0	Detour < 10 miles
5	Detour > 10 miles

Safety Performance Area

- Mainline Daily Traffic Volume
- Vertical Grade
- Shoulder width (Right)
- Elevation
- Interrupted Flow

Mainline Daily Traffic Volume

Exponential equation; score = 5-(5*e$^{(ADT*-0.000039)}$)

Score	Condition
0	<6,000
0-5	6,000-160,000
5	>160,000

Interrupted Flow

Score	Condition
0	Not interrupted flow
5	Interrupted Flow

Elevation

Variance above 4000' divided by 1000; (Elev-4000)/1000

Score	Condition
0	< 4000’
0-5	4000’- 9000’
5 >	9000’

Shoulder (Right side)

Variance below 10'

Score	Condition
0	10’ or above
0-5	10’ - 5’
5	5’ or less

Grade

Variance above 3% x 1.5

Score	Condition
0	< 3%
0-5	3% - 6.33%
5	>6.33%

Freight Performance Area

- Mainline Daily Truck Volume
- Detour Length
- Truck Buffer Index (TPTI-TTTI)

Mainline Daily Truck Volume

Exponential equation; score = 5-(5*e$^{(ADT*-0.00025)}$)

Score	Condition
0	<900
0-5	900-25,000
5	>25,000

Detour Length

Score	Condition
0 Detour	< 10 miles
5 Detour	> 10 miles

Truck Buffer Index

Truck Buffer Index x 10

Score	Condition
0	Buffer Index = 0.00
0-5	Buffer Index 0.00-0.50
5	Buffer Index > 0.50

Appendix E

Performance Effectiveness Scores

Appendix E Performance Effectiveness Scores

Post-Project Performance Scores

		Notes	Description	17-1 Table Mesa	17-2A NB Climbing	17-2B 2 Rev Lanes	17-3 Sunset Point	17-4 NB Climbing	17-5 SB Safety	17-6A New Ramp	17-6B Replace Br	17-7 NB Safety	17-8 SB Climbing	17-9 NB Climbing	17-10 SB Safety	17-11 TI Improve	17-12 NB Climbing
Solution #				17-1	17-2A	17-2B	17-3	17-4	17-5	17-6A	17-6B	17-7	17-8	17-9	17-10	17-11	17-12
Description				Table Mesa	NB Climbing	2 Rev Lanes	Sunset Point	NB Climbing	SB Safety	New Ramp	Replace Br	NB Safety	SB Climbing	NB Climbing	SB Safety	TI Improve	NB Climbing
Project Beg MP				235.5	245	245	252	256	269	293.25	292.75	290	292	294	295	299	299
Project End MP				236.5	251	251	253	260	274	293.75	293.75	292	294	298	298	299	305
Project Length (miles)				1	6	6	1	4	5	0.5	1	2	2	4	3	0	6
Segment Beg MP				232	245	245	245	253	263	288	288	288	288	288	288	288	299
Segment End MP				245	253	253	253	263	279	299	299	299	299	299	299	299	307
Segment Length (miles)				13	8	8	8	10	16	11	11	11	11	11	11	11	8
Segment #				3	4	4	4	5	6	8	8	8	8	8	8	8	9
Current # of Lanes (both directions)				4	4	4	4	4	4	4	4	4	4	4	4	4	4
Project Type (one-way or two-way)				one-way	two-way	two-way	two-way	one-way	one-way	one-way	two-way	one-way	one-way	one-way	one-way	two-way	one-way
Additional Lanes (one-way)				0	1	1	0	1	0	0	0	0	1	1	0	0	1
Pro-Rated # of Lanes				4.00	5.50	5.50	4.00	4.40	4.00	4.00	4.00	4.00	4.18	4.36	4.00	4.00	4.75
SAFETY	DIRECTIONAL SAFETY	Enter current value from performance system (direction 1)	Orig Segment Directional Safety Index (direction 1)	0.667	0.488	0.488	0.488	1.363	1.553	No Change	No Change	2.999	2.084	2.999	2.084	2.999	2.390
		Enter current value from performance system (direction 1)	Orig Segment Directional Fatal Crashes (direction 1)	3	1	1	1	5	4	No Change	No Change	6	4	6	4	6	3
		Enter current value from performance system (direction 1)	Orig Segment Directional Incap Crashes (direction 1)	11	8	8	8	5	8	No Change	No Change	4	5	4	5	4	5
		Enter current value from performance system (direction 1)	Original Fatal Crashes in project limits (direction 1)	0	1	1	0	1	2	No Change	No Change	2	0	2	2	1	0
		Enter current value from performance system (direction 1)	Original Incap Crashes in project limits (direction 1)	1	5	5	3	3	5	No Change	No Change	1	0	1	3	0	4
		User entered value (direction 1)	CMF 1 (direction 1)	0.71	0.75	0.7	0.21	0.75	0.67	No Change	No Change	0.67	0.75	0.75	0.67	0.21	0.75
		User entered value (direction 1)	CMF 2 (direction 1)	1	1	1	1	1	0.54	No Change	No Change	0.54	1	1	0.54	1	1
		User entered value (direction 1)	CMF 3 (direction 1)	1	1	1	1	1	1	No Change	No Change	1	1	1	1	1	1
		Calculated Value (direction 1)	Total CMF (direction 1)	0.710	0.750	0.700	0.210	0.750	0.362			0.362	0.750	0.750	0.362	0.210	0.750
		Calculated Value (direction 1)	Fatal Crash reduction (direction 1)	0.000	0.250	0.300	0.000	0.250	1.276			1.276	0.000	0.500	1.276	0.790	0.000
		Calculated Value (direction 1)	Incap Crash reduction (direction 1)	0.290	1.250	1.500	2.370	0.750	3.191			0.638	0.000	0.250	1.915	0.000	1.000
		Calculated Value (direction 1)	Post-Project Segment Directional Fatal Crashes (direction 1)	3.000	0.750	0.700	1.000	4.750	2.724			4.724	4.000	5.500	2.724	5.210	3.000
		Calculated Value (direction 1)	Post-Project Segment Directional Incap Crashes (direction 1)	10.710	6.750	6.500	5.630	4.250	4.809			3.362	5.000	3.750	3.085	4.000	4.000
		User Entered Value - Enter in Needs spreadsheet to update segment level Safety Need (direction 1)	Post-Project Segment Directional Safety Index (direction 1)	0.664	0.383	0.361	0.437	1.286	1.043	No Change	No Change	2.366	2.084	2.751	1.408	2.621	2.341
		Enter current value from performance system (direction 2)	Orig Segment Directional Safety Index (direction 2)	0.838	1.639	1.639	1.639	0.654	1.092	No Change	No Change	2.084	2.999	2.084	2.999	2.084	1.972
		Enter current value from performance system (direction 2)	Orig Segment Directional Fatal Crashes (direction 2)	0	5	5	5	0	0	No Change	No Change	0	0	0	0	4	0
		Enter current value from performance system (direction 2)	Orig Segment Directional Incap Crashes (direction 2)	0	3	3	3	0	0	No Change	No Change	0	0	0	0	5	0
		Enter current value from performance system (direction 2)	Original Fatal Crashes in project limits (direction 2)	0	5	5	1	0	0	No Change	No Change	0	0	0	0	0	0

				Solution #	17-1	17-2A	17-2B	17-3	17-4	17-5	17-6A	17-6B	17-7	17-8	17-9	17-10	17-11	17-12
MOBILITY		Enter current value from performance system (direction 2)	Original Incap Crashes in project limits (direction 2)		0	1	1	0	0	0	No Change	No Change	0	0	0	0	3	0
		User entered value (direction 2)	CMF 1 (direction 2)		1	0.77	0.65	0.21	1	1	No Change	No Change	1	1	1	1	0.21	1
		User entered value (direction 2)	CMF 1 (direction 2)		1	1	1	1	1	1	No Change	No Change	1	1	1	1	1	1
		User entered value (direction 2)	CMF 1 (direction 2)		1	1	1	1	1	1	No Change	No Change	1	1	1	1	1	1
		Calculated Value (direction 2)	Total CMF (direction 2)		1.000	0.770	0.655	0.210	1.000	1.000			1.000	1.000	1.000	1.000	0.210	1.000
		Calculated Value (direction 2)	Fatal Crash reduction (direction 2)		0.000	1.150	1.728	0.790	0.000	0.000			0.000	0.000	0.000	0.000	0.000	0.000
		Calculated Value (direction 2)	Incap Crash reduction (direction 2)		0.000	0.230	0.346	0.000	0.000	0.000			0.000	0.000	0.000	0.000	2.370	0.000
		Calculated Value (direction 2)	Post-Project Segment Directional Fatal Crashes (direction 2)		0.000	3.850	3.273	4.210	0.000	0.000			0.000	0.000	0.000	0.000	4.000	0.000
		Calculated Value (direction 2)	Post-Project Segment Directional Incap Crashes (direction 2)		0.000	2.770	2.655	3.000	0.000	0.000			0.000	0.000	0.000	0.000	2.630	0.000
		User Entered Value - Enter in Needs spreadsheet to update segment level Safety Need (direction 2)	Post-Project Segment Directional Safety Index (direction 2)		0.838	1.272	1.088	1.390	0.654	1.092	No Change	No Change	2.084	2.999	2.084	2.999	2.005	1.972
		Calculated Value - verify that it matches current performance system	Current Safety Index		0.753	1.064	1.064	1.064	1.009	1.323			2.542	2.542	2.542	2.542	2.542	2.181
		Calculated Value - Enter in Needs spreadsheet to update segment level Safety Need	Post-Project Safety Index		0.751	0.828	0.725	0.914	0.970	1.068	No Change	No Change	2.225	2.542	2.418	2.204	2.313	2.157
	Needs	User entered value from Needs spreadsheet	Original Segment Safety Need		1.308	2.431	2.431	2.431	1.615	3.574	No Change	No Change	7.137	7.137	7.137	7.137	7.137	5.537
		User entered value from Needs spreadsheet	Post-Project Segment Safety Need		1.306	1.477	1.372	1.656	1.411	2.652	No Change	No Change	6.083	7.137	6.726	6.013	6.377	5.514
	MOBILITY INDEX	Enter current value from performance system	Original Segment Mobility Index		0.580	0.640	0.640	0.640	0.590	0.370	No Change	No Change	0.390	0.390	0.390	0.390	0.390	0.410
		Value from above	Post-Project # of Lanes (both directions)		4.00	5.50	5.50	4.00	4.40	4.00			4.00	4.18	4.36	4.00	4.00	4.75
		User Entered Value - Enter in Needs spreadsheet to update segment level Mobility Need	Post-Project Segment Mobility Index		0.580	0.540	0.470	0.640	0.540	0.370	No Change	No Change	0.390	0.380	0.360	0.390	0.390	0.340
	FUT V/C	Enter current value from performance system	Original Segment Future V/C		No Change	0.780	0.780	No Change	0.720	No Change	No Change	No Change	0.470	0.470	0.470	No Change	No Change	0.490
		User Entered Value - Enter in Needs spreadsheet to update segment level Mobility Need	Post-Project Segment Future V/C		No Change	0.660	0.570	No Change	0.660	No Change	No Change	No Change	0.470	0.450	0.430	No Change	No Change	0.410
	PEAK HOUR V/C	Enter current value from performance system (direction 1)	Original Segment Peak Hour V/C (direction 1)		No Change	0.380	0.380	No Change	0.380	No Change	No Change	No Change	0.350	0.350	0.350	No Change	No Change	0.320
		Enter current value from performance system (direction 2)	Original Segment Peak Hour V/C (direction 2)		No Change	0.380	0.380	No Change	0.400	No Change	No Change	No Change	0.350	0.350	0.350	No Change	No Change	0.320
		Calculated value to be used in performance system	Adjusted total # of Lanes for use in directional peak hr		4.00	0.00	0.00	0.00	4.80	4.00			4.00	4.36	4.73	4.00	0.00	5.50
		User Entered Value - Enter in Needs spreadsheet to update segment level Mobility Need	Post-Project Segment Peak Hr V/C (direction 1)		No Change	0.280	0.280	No Change	0.320	No Change	No Change	No Change	0.350	0.320	0.290	No Change	No Change	0.230
		User Entered Value - Enter in Needs spreadsheet to update segment level Mobility Need	Post-Project Segment Peak Hr V/C (direction 2)		No Change	0.380	0.280	No Change	0.400	No Change	No Change	No Change	0.350	0.350	0.350	No Change	No Change	0.320
	TTI AND PTI	Calculated Value (both directions)	Safety Reduction Factor		0.998	0.778	0.681	0.859	0.962	0.807			0.875	1.000	0.951	0.867	0.910	0.989
		Calculated Value (both directions)	Safety Reduction		0.002	0.222	0.319	0.141	0.038	0.193			0.125	0.000	0.049	0.133	0.090	0.011
		Calculated Value (both directions)	Mobility Reduction Factor		1.000	0.844	0.734	1.000	0.915	1.000			1.000	0.974	0.923	1.000	1.000	0.829
		Calculated Value (both directions)	Mobility Reduction		0.000	0.156	0.266	0.000	0.085	0.000			0.000	0.026	0.077	0.000	0.000	0.171
		Assumed effect on TTI (% of mobility reduction)	Mobility effect on TTI		0.30	0.30	0.30	0.30	0.30	0.30			0.30	0.30	0.30	0.30	0.30	0.30
		Assumed effect on PTI (% of mobility reduction)	Mobility effect on PTI		0.20	0.20	0.20	0.20	0.20	0.20			0.20	0.20	0.20	0.20	0.20	0.20

			Solution #	17-1	17-2A	17-2B	17-3	17-4	17-5	17-6A	17-6B	17-7	17-8	17-9	17-10	17-11	17-12
		Assumed effect on TTI (% of safety reduction)	Safety effect on TTI	0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00
		Assumed effect on PTI (% of safety reduction)	Safety effect on PTI	0.30	0.30	0.30	0.30	0.30	0.30			0.30	0.30	0.30	0.30	0.30	0.30
		Enter current value from performance system (direction 1)	Original Directional Segment TTI (direction 1)	1.110	1.210	1.210	1.210	1.200	1.380	No Change	No Change	1.140	1.130	1.140	1.130	1.140	1.300
		Enter current value from performance system (direction 1)	Original Directional Segment PTI (direction 1)	1.200	1.610	1.610	1.610	1.340	1.690	No Change	No Change	1.270	1.240	1.270	1.240	1.270	1.610
		Enter current value from performance system (direction 2)	Original Directional Segment TTI (direction 2)	1.090	1.000	1.000	1.000	1.140	1.130	No Change	No Change	1.130	1.140	1.130	1.140	1.130	1.120
		Enter current value from performance system (direction 2)	Original Directional Segment PTI (direction 2)	1.170	1.070	1.070	1.070	1.210	1.230	No Change	No Change	1.240	1.270	1.240	1.270	1.240	1.220
		Calculated Value (both directions)	Reduction Factor for Segment TTI	0.000	0.047	0.080	0.000	0.025	0.000			0.000	0.008	0.023	0.000	0.000	0.051
		Calculated Value (both directions)	Reduction Factor for Segment PTI	0.001	0.098	0.149	0.042	0.028	0.058			0.037	0.005	0.030	0.040	0.027	0.038
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 1)	Post-Project Directional Segment TTI (direction 1)	1.110	1.153	1.114	1.210	1.169	1.380	No Change	No Change	1.140	1.121	1.114	1.130	1.140	1.233
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 1)	Post-Project Directional Segment PTI (direction 1)	1.199	1.453	1.371	1.542	1.302	1.592	No Change	No Change	1.223	1.234	1.232	1.191	1.236	1.550
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 2)	Post-Project Directional Segment TTTI (direction 2)	1.090	1.000	1.000	1.000	1.140	1.130	No Change	No Change	1.130	1.140	1.130	1.140	1.130	1.120
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 2)	Post-Project Directional Segment TPTI (direction 2)	1.170	1.035	1.035	1.025	1.210	1.230	No Change	No Change	1.240	1.270	1.240	1.270	1.207	1.220
	CLOSURE EXTENT	Enter current value from performance system (direction 1)	Orig Segment Directional Closure Extent (direction 1)	0.110	0.750	0.750	0.750	0.420	0.150	No Change	No Change	0.150	0.220	0.150	0.220	0.150	0.350
		Enter current value from performance system (direction 2)	Orig Segment Directional Closure Extent (direction 2)	0.780	0.610	0.610	0.610	0.280	0.050	No Change	No Change	0.220	0.150	0.220	0.150	0.220	0.200
		Enter value from HCRS	Segment Closures with fatalities/injuries	15	8	8	8	9	8	No Change	No Change	14	14	14	14	14	6
		Enter value from HCRS	Total Segment Closures	31	28	28	28	56	53	No Change	No Change	26	26	26	26	26	31
		Calculated Value (both directions)	% Closures with Fatality/Injury	0.48	0.29	0.29	0.29	0.16	0.15			0.54	0.54	0.54	0.54	0.54	0.19
		Calculated Value (both directions)	Closure Reduction	0.001	0.063	0.091	0.040	0.006	0.029			0.067	0.000	0.026	0.072	0.048	0.002
		Calculated Value (both directions)	Closure Reduction Factor	0.999	0.937	0.909	0.960	0.994	0.971			0.933	1.000	0.974	0.928	0.952	0.998
		Calculated Value - Enter in Needs spreadsheet to update segment level Mobility Need (direction 1)	Post-Project Segment Directional Closure Extent (direction 1)	0.110	0.702	0.682	0.720	0.417	0.146	No Change	No Change	0.140	0.220	0.146	0.204	0.143	0.349
		Calculated Value - Enter in Needs spreadsheet to update segment level Mobility Need (direction 2)	Post-Project Segment Directional Closure Extent (direction 2)	0.780	0.571	0.554	0.585	0.280	0.050	No Change	No Change	0.220	0.150	0.220	0.150	0.209	0.200
	Needs	User entered value from Needs spreadsheet	Original Segment Mobility Need	1.305	2.064	2.064	2.064	1.203	1.124	No Change	No Change	0.680	0.680	0.680	0.680	0.680	1.083
		User entered value from Needs spreadsheet	Post-Project Segment Mobility Need	1.305	1.402	1.106	2.010	1.012	0.998	No Change	No Change	0.675	0.666	0.642	0.670	0.673	0.871
FREIGHT	TTTI AND TPTI	Assumed effect on TTTI (% of mobility reduction)	Mobility effect on TTTI	0.15	0.15	0.15	0.15	0.15	0.15			0.15	0.15	0.15	0.15	0.15	0.15
		Assumed effect on TPTI (% of mobility reduction)	Mobility effect on TPTI	0.10	0.10	0.10	0.10	0.10	0.10			0.10	0.10	0.10	0.10	0.10	0.10
		Assumed effect on TTTI (% of safety reduction)	Safety effect on TTTI	0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00
		Assumed effect on TPTI (% of safety reduction)	Safety effect on TPTI	0.15	0.15	0.15	0.15	0.15	0.15			0.15	0.15	0.15	0.15	0.15	0.15
		Enter current value from performance system (direction 1)	Original Directional Segment TTTI (direction 1)	1.030	1.340	1.340	1.340	1.090	1.270	No Change	No Change	1.080	1.050	1.080	1.050	1.080	1.290
		Enter current value from performance system (direction 1)	Original Directional Segment TPTI (direction 1)	1.090	1.810	1.810	1.810	1.200	1.610	No Change	No Change	1.150	1.110	1.150	1.110	1.150	1.550
		Enter current value from performance system (direction 2)	Original Directional Segment TTTI (direction 2)	1.010	1.070	1.070	1.070	1.020	1.030	No Change	No Change	1.050	1.080	1.050	1.080	1.050	1.060

				Solution #	17-1	17-2A	17-2B	17-3	17-4	17-5	17-6A	17-6B	17-7	17-8	17-9	17-10	17-11	17-12
		Enter current value from performance system (direction 2)	Original Directional Segment TPTI (direction 2)		1.040	1.160	1.160	1.160	1.070	1.080	No Change	No Change	1.110	1.150	1.110	1.150	1.110	1.130
		Calculated Value (both directions)	Reduction Factor for Segment TTTI (both directions)		0.000	0.023	0.040	0.000	0.013	0.000			0.000	0.004	0.012	0.000	0.000	0.026
		Calculated Value (both directions)	Reduction Factor for Segment TPTI (both directions)		0.000	0.049	0.074	0.021	0.014	0.029			0.019	0.003	0.015	0.020	0.013	0.019
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 1)	Post-Project Directional Segment TTTI (direction 1)		1.030	1.309	1.287	1.340	1.076	1.270	No Change	No Change	1.080	1.046	1.068	1.050	1.080	1.257
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 1)	Post-Project Directional Segment TPTI (direction 1)		1.090	1.721	1.675	1.772	1.183	1.563	No Change	No Change	1.129	1.107	1.133	1.088	1.134	1.521
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 2)	Post-Project Directional Segment TTTI (direction 2)		1.010	1.045	1.027	1.070	1.020	1.030	No Change	No Change	1.050	1.080	1.050	1.080	1.050	1.060
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 2)	Post-Project Directional Segment TPTI (direction 2)		1.040	1.103	1.074	1.135	1.070	1.080	No Change		1.110	1.150	1.110	1.150	1.095	1.130
	FREIGHT INDEX	Enter current value from performance system (direction 1)	Original Segment TPTI (direction 1)		1.090	1.810	1.810	1.810	1.200	1.610	No Change	No Change	1.150	1.110	1.150	1.110	1.150	1.550
		Enter current value from performance system (direction 2)	Original Segment TPTI (direction 2)		1.040	1.160	1.160	1.160	1.070	1.080	No Change	No Change	1.110	1.150	1.110	1.150	1.110	1.130
		Calculated Value	Original Segment Freight Index		0.9390	0.673	0.673	0.673	0.881	0.743			0.885	0.885	0.885	0.885	0.885	0.746
		Calculated Value	Post-Project Segment TPTI (direction 1)		1.090	1.721	1.675	1.772	1.183	1.563			1.129	1.107	1.133	1.088	1.134	1.521
		Calculated Value	Post-Project Segment TPTI (direction 2)		1.040	1.103	1.074	1.135	1.070	1.080			1.110	1.150	1.110	1.150	1.095	1.130
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need	Post-Project Segment Freight Index		0.9391	0.708	0.728	0.688	0.888	0.757	No Change	No Change	0.893	0.886	0.892	0.894	0.897	0.754
	CLOSURE DURATION	Enter current value from performance system (direction 1)	Orig Segment Directional Closure Duration (dir 1)		19.720	194.020	194.020	194.020	119.960	24.860	No Change	No Change	32.690	44.200	32.690	44.200	32.690	122.530
		Enter current value from performance system (direction 2)	Orig Segment Directional Closure Duration (dir 2)		209.830	175.250	175.250	175.250	49.380	13.570	No Change	No Change	44.200	32.690	44.200	32.690	44.200	107.000
		Calculated Value	Segment Closures with fatalities		15	8	8	8	9	8			14	14	14	14	14	6
		Calculated Value	Total Segment Closures		31	28	28	28	56	53			26	26	26	26	26	31
		Calculated Value	% Closures with Fatality		0.48	0.29	0.29	0.29	0.16	0.15			0.54	0.54	0.54	0.54	0.54	0.19
		Calculated Value	Closure Reduction		0.001	0.063	0.091	0.040	0.006	0.029			0.067	0.000	0.026	0.072	0.048	0.002
		Calculated Value	Closure Reduction Factor		0.999	0.937	**0.250**	0.960	0.994	0.971			0.933	1.000	0.974	0.928	0.952	0.998
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 1)	Post-Project Segment Directional Closure Duration (direction 1)		19.701	181.719	48.505	186.201	119.224	24.136	No Change	No Change	30.498	44.200	31.831	41.035	31.107	122.264
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 2)	Post-Project Segment Directional Closure Duration (direction 2)		209.830	164.139	43.813	168.188	49.380	13.570	No Change	No Change	44.200	32.690	44.200	32.690	42.060	107.000
	VERT CLR	Enter current value from performance system	Original Vertical Clearance		16.01	No Change	No Change	No Change	No Change	No Change	15.18	15.18	No Change	No Change	No Change	No Change	No Change	No Change
		User Entered Value - Enter in Needs spreadsheet to update segment level Freight Need	Post-Project Vertical Clearance		17.00	No Change	No Change	No Change	No Change	No Change	16.31	16.31	No Change	No Change	No Change	No Change	No Change	No Change
	Needs	User entered value from Needs spreadsheet	Original Segment Freight Need		0.929	3.477	3.477	3.477	0.396	1.015	0.733	0.733	0.733	0.733	0.733	0.733	0.733	1.247
		User entered value from Needs spreadsheet	Post-Project Segment Freight Need		0.535	2.985	2.284	3.214	0.393	0.75	0.353	0.353	0.729	0.733	0.731	0.73	0.728	1.145
BRIDGE	BRIDGEINDEX	Enter current value from performance system	Original Segment Bridge Index		No Change	5.71	5.71	No Change	No Change	No Change	6.04	6.04	No Change	No Change	No Change	No Change	No Change	No Change
		Enter current value from performance system	Original lowest rating for specific bridge		No Change	5	6	No Change	No Change	No Change	4	4	No Change	No Change	No Change	No Change	No Change	No Change
		User entered value (For repair +1, rehab +2, replace=8)	Post-Project lowest rating for specific bridge		No Change	8	8	No Change	No Change	No Change	5	8	No Change	No Change	No Change	No Change	No Change	No Change

				Solution #	17-1	17-2A	17-2B	17-3	17-4	17-5	17-6A	17-6B	17-7	17-8	17-9	17-10	17-11	17-12
		User Entered Value - Enter in Needs spreadsheet to update segment level Bridge Need	Post-Project Bridge Index		No Change	6.58	6.34	No Change	No Change	No Change	6.17	6.57	No Change	No Change	No Change	No Change	No Change	No Change
	SUFF RATING	Enter current value from performance system	Original Segment Sufficiency Rating		No Change	93.97	93.97	No Change	No Change	No Change	89.20	89.20	No Change	No Change	No Change	No Change	No Change	No Change
		Enter current value from performance system	Original Sufficiency Rating for specific bridge		No Change	90.40	95.98	No Change	No Change	No Change	42.64	42.64	No Change	No Change	No Change	No Change	No Change	No Change
		User entered value (For repair +10, rehab +20, replace=98)	Post-Project Sufficiency Rating for specific bridge		No Change	98.00	98.00	No Change	No Change	No Change	52.64	98.00	No Change	No Change	No Change	No Change	No Change	No Change
		User Entered Value - Enter in Needs spreadsheet to update segment level Bridge Need	Post-Project Segment Sufficiency Rating		No Change	96.19	94.61	No Change	No Change	No Change	90.52	96.53	No Change	No Change	No Change	No Change	No Change	No Change
	BR RTNG	Enter current value from performance system	Original Segment Bridge Rating		No Change	5	5	No Change	No Change	No Change	4	4	No Change	No Change	No Change	No Change	No Change	No Change
		User Entered Value - Enter in Needs spreadsheet to update segment level Bridge Need	Post-Project Segment Bridge Rating		No Change	6	5	No Change	No Change	No Change	5	5	No Change	No Change	No Change	No Change	No Change	No Change
	% FUN OB	Enter current value from performance system	Original Segment % Functionally Obsolete		No Change	60.88%	60.88%	No Change	No Change	No Change	13.55%	13.55%	No Change	No Change	No Change	No Change	No Change	No Change
		User Entered Value - Enter in Needs spreadsheet to update segment level Bridge Need (only remove from FO if replace or rehab)	Post-Project Segment % Functionally Obsolete		No Change	31.67%	29.21%	No Change	No Change	No Change	13.55%	13.55%	No Change	No Change	No Change	No Change	No Change	No Change
	Needs	User entered value from Needs spreadsheet	Original Segment Bridge Need		No Change	1.496	1.496	No Change	No Change	No Change	0.792	0.792	No Change	No Change	No Change	No Change	No Change	No Change
		User entered value from Needs spreadsheet	Post-Project Segment Bridge Need		No Change	0.154	0.392	No Change	No Change	No Change	0.462	0.132	No Change	No Change	No Change	No Change	No Change	No Change
PAVEMENT	PAVEMENT INDEX	Enter current value from performance system	Original Segment Pavement Index		3.85	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
		Enter current value from performance system	Original Segment IRI in project limits		78-80	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
		Enter current value from performance system	Original Segment Cracking in project limits		5-8	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
		For rehab, increase to 45; for replace increase to 30 (enter in Pvmt performance tool to calculate new performance)	Post-Project IRI in project limits		30	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
		Lower to 0 for rehab or replace (enter in Pvmt performance tool to calculate new performance)	Post-Project Cracking in project limits		0	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
		User Entered Value - Enter in Needs spreadsheet to update segment level Pavement Need (from Pvmt performance tool)	Post-Project Pavement Index		3.92	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
	DIRECTION PSR	Enter current value from performance system (direction 1)	Original Segment Directional PSR (direction 1)		3.86	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
		Enter current value from performance system (direction 2)	Original Segment Directional PSR (direction 2)		3.92													
		Value from above	Original Segment IRI in project limits		78-80	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
		Value from above	Post-Project directional IRI in project limits		30	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
		User Entered Value - Enter in Needs spreadsheet to update segment level Pavement Need (from Pvmt performance tool)	Post-Project Directional PSR (direction 1)		3.98	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
		User Entered Value - Enter in Needs spreadsheet to update segment level Pavement Need (from Pvmt performance tool)	Post-Project Directional PSR (direction 2)		3.92	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
	% FAIL	Enter current value from performance system	Original Segment % Failure		3.8%	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
		User Entered Value - Enter in Needs spreadsheet to update segment level Pavement Need (from Pvmt performance tool)	Post-Project Segment % Failure		3.8%	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
	Needs	User entered value from Needs spreadsheet	Original Segment Pavement Need		0.038	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
		User entered value from Needs spreadsheet	Post-Project Segment Pavement Need		0.038	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change

			Solution #	**17-13**	**17-14**	**17-15**	**17-16**	**17-17A**	**17-17B**
			Description	SB Safety	NB Safety	SB Safety	SB Climbing	Replace Deck	Realign
			Project Beg MP	300	306	311	316	316.5	316.5
			Project End MP	302	307	313	317	317.5	317.5
			Project Length (miles)	2	1	2	1	1	1
			Segment Beg MP	299	299	307	307	316	316
			Segment End MP	307	307	316	316	323	323
			Segment Length (miles)	8	8	9	9	7	7
			Segment #	9	9	10	11	11	11
			Current # of Lanes (both directions)	4	4	4	4	4	4
			Project Type (one-way or two-way)	one-way	one-way	one-way	one-way	two-way	two-way
			Additional Lanes (one-way)	0	0	0	1	0	0
			Pro-Rated # of Lanes	4.00	4.00	4.00	4.11	4.00	4.00
		Notes	**Description**						
SAFETY	DIRECTIONAL SAFETY	Enter current value from performance system (direction 1)	Orig Segment Directional Safety Index (direction 1)	1.972	2.390	0.909	0.238	2.189	2.189
		Enter current value from performance system (direction 1)	Orig Segment Directional Fatal Crashes (direction 1)	2	3	1	0	2	2
		Enter current value from performance system (direction 1)	Orig Segment Directional Incap Crashes (direction 1)	11	5	5	4	8	8
		Enter current value from performance system (direction 1)	Original Fatal Crashes in project limits (direction 1)	2	2	1	0	1	1
		Enter current value from performance system (direction 1)	Original Incap Crashes in project limits (direction 1)	5	1	0	1	4	4
		User entered value (direction 1)	CMF 1 (direction 1)	0.67	0.67	0.67	0.75	0.7	0.43
		User entered value (direction 1)	CMF 2 (direction 1)	0.54	0.54	0.54	1	1	1
		User entered value (direction 1)	CMF 3 (direction 1)	1	1	1	1	1	1
		Calculated Value (direction 1)	Total CMF (direction 1)	0.362	0.362	0.362	0.750	0.700	0.430
		Calculated Value (direction 1)	Fatal Crash reduction (direction 1)	1.276	1.276	0.638	0.000	0.300	0.570
		Calculated Value (direction 1)	Incap Crash reduction (direction 1)	3.191	0.638	0.000	0.250	1.200	2.280
		Calculated Value (direction 1)	Post-Project Segment Directional Fatal Crashes (direction 1)	0.724	1.724	0.362	0.000	1.700	1.430
		Calculated Value (direction 1)	Post-Project Segment Directional Incap Crashes (direction 1)	7.809	4.362	5.000	3.750	6.800	5.720
		User Entered Value - Enter in Needs spreadsheet to update segment level Safety Need (direction 1)	Post-Project Segment Directional Safety Index (direction 1)	0.902	1.445	0.478	0.223	1.861	1.565
		Enter current value from performance system (direction 2)	Orig Segment Directional Safety Index (direction 2)	2.390	1.972	0.805	2.189	0.238	0.238
		Enter current value from performance system (direction 2)	Orig Segment Directional Fatal Crashes (direction 2)	0	0	0	0	0	0
		Enter current value from performance system (direction 2)	Orig Segment Directional Incap Crashes (direction 2)	0	0	0	0	4	4
		Enter current value from performance system (direction 2)	Original Fatal Crashes in project limits (direction 2)	0	0	0	0	0	0
		Enter current value from performance system (direction 2)	Original Incap Crashes in project limits (direction 2)	0	0	0	0	1	2
		User entered value (direction 2)	CMF 1 (direction 2)	1	1	1	1	0.7	0.43
		User entered value (direction 2)	CMF 1 (direction 2)	1	1	1	1	1	1

				Solution #	17-13	17-14	17-15	17-16	17-17A	17-17B
		User entered value (direction 2)	CMF 1 (direction 2)		1	1	1	1	1	1
		Calculated Value (direction 2)	Total CMF (direction 2)		1.000	1.000	1.000	1.000	0.700	0.430
		Calculated Value (direction 2)	Fatal Crash reduction (direction 2)		0.000	0.000	0.000	0.000	0.000	0.000
		Calculated Value (direction 2)	Incap Crash reduction (direction 2)		0.000	0.000	0.000	0.000	0.300	1.140
		Calculated Value (direction 2)	Post-Project Segment Directional Fatal Crashes (direction 2)		0.000	0.000	0.000	0.000	0.000	0.000
		Calculated Value (direction 2)	Post-Project Segment Directional Incap Crashes (direction 2)		0.000	0.000	0.000	0.000	3.700	2.860
		User Entered Value - Enter in Needs spreadsheet to update segment level Safety Need (direction 2)	Post-Project Segment Directional Safety Index (direction 2)		2.390	1.972	0.805	2.189	0.220	0.170
		Calculated Value - verify that it matches current performance system	Current Safety Index		2.181	2.181	0.857	1.214	1.214	1.214
		Calculated Value - Enter in Needs spreadsheet to update segment level Safety Need	Post-Project Safety Index		1.646	1.709	0.642	1.206	1.041	0.868
	Needs	User entered value from Needs spreadsheet	Original Segment Safety Need		5.537	5.537	0.865	2.613	2.613	2.613
		User entered value from Needs spreadsheet	Post-Project Segment Safety Need		3.705	3.963	0.723	2.590	1.904	1.068
MOBILITY	**MOBILITY INDEX**	Enter current value from performance system	Original Segment Mobility Index		0.410	0.410	0.350	0.290	0.290	0.290
		Value from above	Post-Project # of Lanes (both directions)		4.00	4.00	4.00	4.11	4.00	4.00
		User Entered Value - Enter in Needs spreadsheet to update segment level Mobility Need	Post-Project Segment Mobility Index		0.410	0.410	0.350	0.280	0.290	0.290
	FUT V/C	Enter current value from performance system	Original Segment Future V/C		0.490	No Change	No Change	0.340	No Change	No Change
		User Entered Value - Enter in Needs spreadsheet to update segment level Mobility Need	Post-Project Segment Future V/C		0.490	No Change	No Change	0.330	No Change	No Change
	PEAK HOUR V/C	Enter current value from performance system (direction 1)	Original Segment Peak Hour V/C (direction 1)		0.320	No Change	No Change	0.210	No Change	No Change
		Enter current value from performance system (direction 2)	Original Segment Peak Hour V/C (direction 2)		0.320	No Change	No Change	0.230	No Change	No Change
		Calculated value to be used in performance system	Adjusted total # of Lanes for use in directional peak hr		4.00	4.00	4.00	4.22	0.00	0.00
		User Entered Value - Enter in Needs spreadsheet to update segment level Mobility Need	Post-Project Segment Peak Hr V/C (direction 1)		0.320	No Change	No Change	0.200	No Change	No Change
		User Entered Value - Enter in Needs spreadsheet to update segment level Mobility Need	Post-Project Segment Peak Hr V/C (direction 2)		0.320	No Change	No Change	0.230	No Change	No Change
	TTI AND PTI	Calculated Value (both directions)	Safety Reduction Factor		0.755	0.783	0.749	0.994	0.857	0.715
		Calculated Value (both directions)	Safety Reduction		0.245	0.217	0.251	0.006	0.143	0.285
		Calculated Value (both directions)	Mobility Reduction Factor		1.000	1.000	1.000	0.966	1.000	1.000
		Calculated Value (both directions)	Mobility Reduction		0.000	0.000	0.000	0.034	0.000	0.000
		Assumed effect on TTI (% of mobility reduction)	Mobility effect on TTI		0.30	0.30	0.30	0.30	0.30	0.30
		Assumed effect on PTI (% of mobility reduction)	Mobility effect on PTI		0.20	0.20	0.20	0.20	0.20	0.20
		Assumed effect on TTI (% of safety reduction)	Safety effect on TTI		0.00	0.00	0.00	0.00	0.00	0.00
		Assumed effect on PTI (% of safety reduction)	Safety effect on PTI		0.30	0.30	0.30	0.30	0.30	0.30

				Solution #	17-13	17-14	17-15	17-16	17-17A	17-17B
		Enter current value from performance system (direction 1)	Original Directional Segment TTI (direction 1)		1.120	1.300	1.130	1.080	1.100	1.100
		Enter current value from performance system (direction 1)	Original Directional Segment PTI (direction 1)		1.220	1.610	1.250	1.160	1.180	1.180
		Enter current value from performance system (direction 2)	Original Directional Segment TTI (direction 2)		1.300	1.120	1.290	1.100	1.080	1.080
		Enter current value from performance system (direction 2)	Original Directional Segment PTI (direction 2)		1.610	1.220	1.600	1.180	1.160	1.160
		Calculated Value (both directions)	Reduction Factor for Segment TTI		0.000	0.000	0.000	0.010	0.000	0.000
		Calculated Value (both directions)	Reduction Factor for Segment PTI		0.074	0.065	0.075	0.009	0.043	0.086
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 1)	Post-Project Directional Segment TTI (direction 1)		1.120	1.300	1.130	1.069	1.100	1.100
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 1)	Post-Project Directional Segment PTI (direction 1)		1.130	1.505	1.156	1.150	1.130	1.079
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 2)	Post-Project Directional Segment TTTI (direction 2)		1.300	1.120	1.290	1.100	1.080	1.080
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 2)	Post-Project Directional Segment TPTI (direction 2)		1.610	1.220	1.600	1.180	1.110	1.061
	CLOSURE EXTENT	Enter current value from performance system (direction 1)	Orig Segment Directional Closure Extent (direction 1)		0.200	0.350	0.290	0.290	0.000	0.000
		Enter current value from performance system (direction 2)	Orig Segment Directional Closure Extent (direction 2)		0.350	0.200	0.200	0.000	0.290	0.290
		Enter value from HCRS	Segment Closures with fatalities/injuries		6	6	4	9	2	2
		Enter value from HCRS	Total Segment Closures		31	31	26	29	19	19
		Calculated Value (both directions)	% Closures with Fatality/Injury		0.19	0.19	0.15	0.31	0.11	0.11
		Calculated Value (both directions)	Closure Reduction		0.047	0.042	0.039	0.002	0.015	0.030
		Calculated Value (both directions)	Closure Reduction Factor		0.953	0.958	0.961	0.998	0.985	0.970
		Calculated Value - Enter in Needs spreadsheet to update segment level Mobility Need (direction 1)	Post-Project Segment Directional Closure Extent (direction 1)		0.191	0.335	0.279	0.289	0.000	0.000
		Calculated Value - Enter in Needs spreadsheet to update segment level Mobility Need (direction 2)	Post-Project Segment Directional Closure Extent (direction 2)		0.350	0.200	0.200	0.000	0.286	0.281
	Needs	User entered value from Needs spreadsheet	Original Segment Mobility Need		1.083	1.083	0.991	0.537	0.537	0.537
		User entered value from Needs spreadsheet	Post-Project Segment Mobility Need		1.075	1.002	0.986	0.526	0.533	0.529
FREIGHT	TTTI AND TPTI	Assumed effect on TTTI (% of mobility reduction)	Mobility effect on TTTI		0.15	0.15	0.15	0.15	0.15	0.15
		Assumed effect on TPTI (% of mobility reduction)	Mobility effect on TPTI		0.10	0.10	0.10	0.10	0.10	0.10
		Assumed effect on TTTI (% of safety reduction)	Safety effect on TTTI		0.00	0.00	0.00	0.00	0.00	0.00
		Assumed effect on TPTI (% of safety reduction)	Safety effect on TPTI		0.15	0.15	0.15	0.15	0.15	0.15
		Enter current value from performance system (direction 1)	Original Directional Segment TTTI (direction 1)		1.060	1.290	1.070	1.020	1.030	1.030
		Enter current value from performance system (direction 1)	Original Directional Segment TPTI (direction 1)		1.130	1.550	1.150	1.060	1.070	1.070
		Enter current value from performance system (direction 2)	Original Directional Segment TTTI (direction 2)		1.290	1.060	1.250	1.030	1.020	1.020

			Solution #	17-13	17-14	17-15	17-16	17-17A	17-17B
		Enter current value from performance system (direction 2)	Original Directional Segment TPTI (direction 2)	1.550	1.130	1.570	1.070	1.060	1.060
		Calculated Value (both directions)	Reduction Factor for Segment TTTI (both directions)	0.000	0.000	0.000	0.005	0.000	0.000
		Calculated Value (both directions)	Reduction Factor for Segment TPTI (both directions)	0.037	0.032	0.038	0.004	0.021	0.043
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 1)	Post-Project Directional Segment TTTI (direction 1)	1.060	1.290	1.070	1.015	1.030	1.030
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 1)	Post-Project Directional Segment TPTI (direction 1)	1.088	1.500	1.107	1.055	1.047	1.024
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 2)	Post-Project Directional Segment TTTI (direction 2)	1.290	1.060	1.250	1.030	1.020	1.020
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 2)	Post-Project Directional Segment TPTI (direction 2)	1.550	1.130	1.570	1.070	1.037	1.015
	FREIGHT INDEX	Enter current value from performance system (direction 1)	Original Segment TPTI (direction 1)	1.130	1.550	1.150	1.060	1.070	1.070
		Enter current value from performance system (direction 2)	Original Segment TPTI (direction 2)	1.550	1.130	1.570	1.070	1.060	1.060
		Calculated Value	Original Segment Freight Index	0.746	0.746	0.735	0.939	0.939	0.939
		Calculated Value	Post-Project Segment TPTI (direction 1)	1.088	1.500	1.107	1.055	1.047	1.024
		Calculated Value	Post-Project Segment TPTI (direction 2)	1.550	1.130	1.570	1.070	1.037	1.015
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need	Post-Project Segment Freight Index	0.758	0.761	0.747	0.941	0.959	0.981
	CLOSURE DURATION	Enter current value from performance system (direction 1)	Orig Segment Directional Closure Duration (dir 1)	107.000	122.530	121.240	124.430	0.000	0.000
		Enter current value from performance system (direction 2)	Orig Segment Directional Closure Duration (dir 2)	122.530	107.000	41.700	0.000	124.430	124.430
		Calculated Value	Segment Closures with fatalities	6	6	4	9	2	2
		Calculated Value	Total Segment Closures	31	31	26	29	19	19
		Calculated Value	% Closures with Fatality	0.19	0.19	0.15	0.31	0.11	0.11
		Calculated Value	Closure Reduction	0.047	0.042	0.039	0.002	0.015	0.030
		Calculated Value	Closure Reduction Factor	0.953	0.958	0.961	0.998	0.985	0.970
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 1)	Post-Project Segment Directional Closure Duration (direction 1)	101.920	117.392	116.550	124.191	0.000	0.000
		Calculated Value - Enter in Needs spreadsheet to update segment level Freight Need (direction 2)	Post-Project Segment Directional Closure Duration (direction 2)	122.530	107.000	41.700	0.000	122.563	120.695
	VERT CLR	Enter current value from performance system	Original Vertical Clearance	No Change	No Change	No Change	No Change	No Change	No Change
		User Entered Value - Enter in Needs spreadsheet to update segment level Freight Need	Post-Project Vertical Clearance	No Change	No Change	No Change	No Change	No Change	No Change
	Needs	User entered value from Needs spreadsheet	Original Segment Freight Need	1.247	1.247	1.152	0.362	0.362	0.362
		User entered value from Needs spreadsheet	Post-Project Segment Freight Need	1.038	1.113	1.087	0.362	0.357	0.352

				Solution #	17-13	17-14	17-15	17-16	17-17A	17-17B
BRIDGE	BRIDGEINDEX	Enter current value from performance system	Original Segment Bridge Index		No Change	No Change	No Change	No Change	6.91	6.91
		Enter current value from performance system	Original lowest rating for specific bridge		No Change	No Change	No Change	No Change	7	7
		User entered value (For repair +1, rehab +2, replace=8)	Post-Project lowest rating for specific bridge		No Change	No Change	No Change	No Change	7	8
		User Entered Value - Enter in Needs spreadsheet to update segment level Bridge Need	Post-Project Bridge Index		No Change	No Change	No Change	No Change	6.91	7.15
	SUFF RATING	Enter current value from performance system	Original Segment Sufficiency Rating		No Change	No Change	No Change	No Change	96.48	96.48
		Enter current value from performance system	Original Sufficiency Rating for specific bridge		No Change	No Change	No Change	No Change	97.36	97.36
		User entered value (For repair +10, rehab +20, replace=98)	Post-Project Sufficiency Rating for specific bridge		No Change	No Change	No Change	No Change	97.36	98.00
		User Entered Value - Enter in Needs spreadsheet to update segment level Bridge Need	Post-Project Segment Sufficiency Rating		No Change	No Change	No Change	No Change	96.48	96.63
	BR RTNG	Enter current value from performance system	Original Segment Bridge Rating		No Change	No Change	No Change	No Change	5	5
		User Entered Value - Enter in Needs spreadsheet to update segment level Bridge Need	Post-Project Segment Bridge Rating		No Change	No Change	No Change	No Change	5	5
	% FUN OB	Enter current value from performance system	Original Segment % Functionally Obsolete		No Change	No Change	No Change	No Change	3.41%	3.41%
		User Entered Value - Enter in Needs spreadsheet to update segment level Bridge Need (only remove from FO if replace or rehab)	Post-Project Segment % Functionally Obsolete		No Change	No Change	No Change	No Change	3.41%	3.41%
	Needs	User entered value from Needs spreadsheet	Original Segment Bridge Need		No Change	No Change	No Change	No Change	0.108	0.108
		User entered value from Needs spreadsheet	Post-Project Segment Bridge Need		No Change	No Change	No Change	No Change	0.108	0.108
PAVEMENT	PAVEMENT INDEX	Enter current value from performance system	Original Segment Pavement Index		No Change	No Change	No Change	No Change	2.73	3.73
		Enter current value from performance system	Original Segment IRI in project limits		No Change	No Change	No Change	No Change	70-104	70-105
		Enter current value from performance system	Original Segment Cracking in project limits		No Change	No Change	No Change	No Change	3-8	3-9
		For rehab, increase to 45; for replace increase to 30 (enter in Pvmt performance tool to calculate new performance)	Post-Project IRI in project limits		No Change	No Change	No Change	No Change	30	30
		Lower to 0 for rehab or replace (enter in Pvmt performance tool to calculate new performance)	Post-Project Cracking in project limits		No Change	No Change	No Change	No Change	0	0
		User Entered Value - Enter in Needs spreadsheet to update segment level Pavement Need (from Pvmt performance tool)	Post-Project Pavement Index		No Change	No Change	No Change	No Change	3.99	3.99
	DIRECTION PSR	Enter current value from performance system (direction 1)	Original Segment Directional PSR (direction 1)		No Change	No Change	No Change	No Change	3.50	3.50
		Enter current value from performance system (direction 2)	Original Segment Directional PSR (direction 2)						3.82	3.82
		Value from above	Original Segment IRI in project limits		No Change	No Change	No Change	No Change	70-104	70-105
		Value from above	Post-Project directional IRI in project limits		No Change	No Change	No Change	No Change	30	30
		User Entered Value - Enter in Needs spreadsheet to update segment level Pavement Need (from Pvmt performance tool)	Post-Project Directional PSR (direction 1)		No Change	No Change	No Change	No Change	3.80	3.80
		User Entered Value - Enter in Needs spreadsheet to update segment level Pavement Need (from Pvmt performance tool)	Post-Project Directional PSR (direction 2)		No Change	No Change	No Change	No Change	4.03	4.03

				Solution #	17-13	17-14	17-15	17-16	17-17A	17-17B
	% FAIL	Enter current value from performance system	Original Segment % Failure		No Change	No Change	No Change	No Change	21.4%	21.4%
		User Entered Value - Enter in Needs spreadsheet to update segment level Pavement Need (from Pvmt performance tool)	Post-Project Segment % Failure		No Change	No Change	No Change	No Change	14.3%	14.3%
	Needs	User entered value from Needs spreadsheet	Original Segment Pavement Need		No Change	No Change	No Change	No Change	0.594	0.594
		User entered value from Needs spreadsheet	Post-Project Segment Pavement Need		No Change	No Change	No Change	No Change	0.272	0.272

Performance Area Risk Factors

Solution Number	Mainline Traffic Vol (vpd) (2-way)	Solution Length (miles)	Bridge Detour Length (miles) (N19)	Elevation (ft)	Scour Critical Rating (0-9)	Carries Mainline Traffic (Y/N)	Bridge Vert. Clear (ft)	Mainline Truck Vol (vpd) (2-way)	Detour Length > 10 miles (Y/N)	Truck Buffer Index	Non-Truck Buffer Index	Grade (%)	Interrupted Flow (Y/N)	Outside/ Right Shoulder Width (ft)
1	33,072			2,260				4,200	y	0.06		3	n	10
2	29,683	6	1	3,350	8	n	16.00	3,770	y	0.47	0.4	6	n	10
3	29,683	1		3,400				3,770	y	0.47	0.4	4.4	n	10
4	27,138	4		3,700				3,447	y	0.11	0.14	5	n	10
5	20,208	5		4,250				3,080	y	0.34	0.31	5.2	n	10
6	22,377		12	3,300	8	n	15.18	3,153	y	0.07				
7	22,377	2		3,400				3,153	y	0.07	0.13	2.4	n	10
8	22,377	2		3,425				3,153	y	0.06	0.11	4	n	10
9	22,377	4		3,800				3,153	y	0.07	0.13	5.9	n	10
10	22,377	3		3,800				3,153	y	0.06	0.11	5.6	n	10
11	22,377	1		3,850				3,153	y	0.26	0.13	4.2	n	10
12	18,951	6		5,325				2,740	y	0.26	0.31	6	n	10
13	18,951	2		4,625				2,740	y	0.07	0.1	6	n	10
14	18,951	1		5,425				2,740	y	0.26	0.31	4	n	10
15	16,031	2		6,400				2,318	y	0.08	0.12	6	n	10
16	16,244	1		6,475				2,606	y	0.04	0.08	4	n	10
17	16,244	1	1	6,330	8	y	16.00	2,606	y	0.04	0.08	3.7	n	10

Performance Area Risk Factors

Solution Number	Bridge	Pavement	Mobility	Safety	Freight	Risk Score (0 to 10)				
						Bridge	Pavement	Mobility	Safety	Freight
1	n	n	N	Y	y	0.00	0.00	0.00	1.44	5.91
2	y	N	y	Y	Y	1.30	0.00	9.05	3.16	8.51
3	n	N	y	y	y	0.00	0.00	7.13	2.20	8.51
4	N	N	y	Y	y	0.00	0.00	6.86	2.50	6.00
5	N	N	y	y	y	0.00	0.00	7.91	2.50	7.40
6	Y	N	N	N	y	3.31	0.00	0.00	0.00	5.62
7	N	N	y	Y	y	0.00	0.00	5.74	1.16	5.62
8	N	N	Y	Y	Y	0.00	0.00	5.61	1.76	5.56
9	N	N	Y	Y	Y	0.00	0.00	6.57	2.90	5.62
10	N	N	y	Y	y	0.00	0.00	6.09	2.72	5.56
11	N	N	y	y	y	0.00	0.00	5.09	1.88	6.89
12	N	N	Y	Y	Y	0.00	0.00	8.05	3.37	6.73
13	N	N	y	Y	y	0.00	0.00	5.36	3.09	5.46
14	N	N	y	y	y	0.00	0.00	6.17	2.21	6.73
15	N	N	y	Y	y	0.00	0.00	5.33	3.68	5.34
16	N	N	y	Y	y	0.00	0.00	4.54	2.52	5.20
17	y	y	y	Y	y	3.39	4.71	4.54	2.28	5.20

Performance Effectiveness Scores – Five Performance Areas

Candidate Solution #	Candidate Solution Name	Milepost Location	Estimated Cost ($ millions)	Pavement					Bridge					Safety					Mobility					Freight				
				Existing Need	Post-Solution Need	Raw Score	Risk Factor	Factored Score	Existing Need	Post-Solution Need	Raw Score	Risk Factor	Factored Score	Existing Need	Post-Solution Need	Raw Score	Risk Factor	Factored Score	Existing Need	Post-Solution Need	Raw Score	Risk Factor	Factored Score	Existing Need	Post-Solution Need	Raw Score	Risk Factor	Factored Score
CS17.01	Table Mesa TI	236	2.37	0.038	0.038	0.00		0.000			0.00		0.000	1.308	1.306	0.00	1.44	0.003	1.305	1.305	0.000		0.000	0.929	0.535	0.394	5.91	2.329
CS17.02 - A	Black Canyon Hill Option A - Northbound Climbing Lane	NB 245-251	51.42			0.00		0.000	1.496	0.154	1.34	1.3	1.745	2.431	1.477	0.95	3.16	3.015	2.064	1.402	0.662	9.05	5.991	3.477	2.724	0.753	8.51	6.408
CS17.02 - B	Black Canyon Hill Option B - Two Reversible Lanes	NB 245-251	148.82			0.00		0.000	1.496	0.392	1.10	1.3	1.435	2.431	1.372	1.06	3.16	3.346	2.064	1.106	0.958	9.05	8.670	3.477	1.748	1.729	8.51	14.714
CS17.03	Sunset Point TI	252-253	4.63			0.00		0.000			0.00		0.000	2.431	1.656	0.78	2.20	1.705	2.064	2.01	0.054	7.13	0.385	3.477	3.214	0.263	8.51	2.238
CS17.04	Badger Springs Climbing Lane	NB 256-260	14.9			0.00		0.000			0.00		0.000	1.615	1.411	0.20	2.50	0.510	1.203	1.012	0.191	6.86	1.310	0.396	0.393	0.003	6.00	0.018
CS17.05	Orme Rd Safety Improvements	SB 269-274	4.52			0.00		0.000			0.00		0.000	3.574	2.652	0.92	2.50	2.305	1.124	0.998	0.126	7.91	0.997	1.015	0.75	0.265	7.40	1.961
CS17.06 - A	McGuireville TI - Option A (New Ramp)	239.25-239.75	5.85			0.00		0.000	0.792	0.462	0.33	3.31	1.092			0.00		0.000			0.000		0.000	0.733	0.353	0.380	5.62	2.136
CS17.06 - B	McGuireville TI - Option B (Replace Bridge)	238.75-239.75	18.32			0.00		0.000	0.792	0.132	0.66	3.31	2.185			0.00		0.000			0.000		0.000	0.733	0.353	0.380	5.62	2.136
CS17.07	Middle Verde Road Safety Improvements	NB 290-292	1.92			0.00		0.000			0.00		0.000	7.137	6.083	1.05	1.16	1.223	0.680	0.675	0.005	5.74	0.029	0.733	0.729	0.004	5.62	0.022
CS17.08	Dry Beaver Creek Southbound Climbing Lane	SB 292-294	9.35			0.00		0.000			0.00		0.000	7.137	7.137	0.00	1.76	0.000	0.680	0.666	0.014	5.61	0.079	0.733	0.733	0.000	5.56	0.000
CS17.09	Dry Beaver Creek Northbound Climbing Lane	NB 294-298	14.90			0.00		0.000			0.00		0.000	7.137	6.726	0.41	2.90	1.192	0.680	0.642	0.038	6.57	0.250	0.733	0.731	0.002	5.62	0.011
CS17.10	McGuireville Rest Area Safety Improvements	SB 295-298	2.83			0.00		0.000			0.00		0.000	7.137	6.013	1.12	2.72	3.057	0.680	0.676	0.004	6.09	0.024	0.733	0.730	0.003	5.56	0.017

Candidate Solution #	Candidate Solution Name	Milepost Location	Estimated Cost ($ millions)	Pavement					Bridge					Safety					Mobility					Freight				
				Existing Need	Post-Solution Need	Raw Score	Risk Factor	Factored Score	Existing Need	Post-Solution Need	Raw Score	Risk Factor	Factored Score	Existing Need	Post-Solution Need	Raw Score	Risk Factor	Factored Score	Existing Need	Post-Solution Need	Raw Score	Risk Factor	Factored Score	Existing Need	Post-Solution Need	Raw Score	Risk Factor	Factored Score
CS17.11	SR 179 TI	299	4.97			0.00		0.000			0.00		0.000	7.137	6.377	0.76	1.88	1.429	0.680	0.675	0.005	5.09	0.025	0.733	0.729	0.004	6.89	0.028
CS17.12	Hog Tank Canyon Northbound Climbing Lane	NB 299-305	23.05			0.00		0.000			0.00		0.000	5.537	5.514	0.02	3.37	0.078	1.083	0.875	0.208	8.05	1.674	1.247	1.155	0.092	6.73	0.619
CS17.13	Hog Tank Canyon Southbound Safety Improvements	SB 300-302	4.52			0.00		0.000			0.00		0.000	5.537	3.705	1.83	3.09	5.661	1.083	1.078	0.005	5.36	0.027	1.247	1.173	0.074	5.46	0.404
CS17.14	Rattlesnake Canyon Safety Improvements	NB 306-307	2.15			0.00		0.000			0.00		0.000	5.537	3.963	1.57	2.21	3.479	1.083	1.002	0.081	6.17	0.500	1.247	1.113	0.134	6.73	0.902
CS17.15	Red Hill Scenic Overlook Safety Improvements	SB 311-313	6.33			0.00		0.000			0.00		0.000	0.865	0.723	0.14	3.68	0.523	0.991	0.986	0.005	5.33	0.027	1.152	1.087	0.065	5.34	0.347
CS17.16	Woods Canyon Climbing Lane	SB 316-317	5.65			0.00		0.000			0.00		0.000	2.613	2.59	0.02	2.52	0.058	0.537	0.526	0.011	4.54	0.050	0.362	0.362	0.000	5.20	0.000
CS17.17	Woods Canyon - Realign roadway	316.5 - 317.5	37.06	0.594	0.272	0.32	4.71	1.517			0.00		0.000	2.613	1.068	1.55	2.28	3.523	0.537	0.529	0.008	4.54	0.036	0.362	0.352	0.010	5.20	0.052

Performance Effectiveness Scores – Emphasis Areas and Results

Candidate Solution #	Candidate Solution Name	Milepost Location	Estimated Cost ($ millions)	Safety Emphasis Area						Mobility Emphasis Area						Total Factored Score	VMT/10,000	Performance Effectiveness Score (Total Factored Score x 100/Cost x VMT/10,000)
				Existing Corridor Need	Post-Solution Corridor Need	Raw Score	Risk Factor	Emphasis Factor	Factored Score	Existing Corridor Need	Post-Solution Corridor Need	Raw Score	Risk Factor	Emphasis Factor	Factored Score			
CS17.01	Table Mesa TI	236	2.37	2.532	2.531	0.001	1.44	2.25	0.003	0.436	0.436	0		2.25	0.000	2.335	0.83	81.4
CS17.02 - A	Black Canyon Hill Option A - Northbound Climbing Lane	NB 245-251	51.42	2.532	2.491	0.041	3.16	2.25	0.292	0.436	0.430	0.006	9.05	2.25	0.122	17.572	17.81	608.6
CS17.02 - B	Black Canyon Hill Option B - Two Reversible Lanes	NB 245-251	148.82	2.532	2.473	0.059	3.16	2.25	0.419	0.436	0.426	0.01	9.05	2.25	0.204	28.788	17.81	344.5
CS17.03	Sunset Point TI	252-253	4.63	2.532	2.506	0.026	2.20	2.25	0.129	0.436	0.436	0	7.13	2.25	0.000	4.457	2.97	285.7
CS17.04	Badger Springs Climbing Lane	NB 256-260	14.9	2.532	2.523	0.009	2.50	2.25	0.051	0.436	0.432	0.004	6.86	2.25	0.062	1.951	5.43	71.1
CS17.05	Orme Rd Safety Improvements	SB 269-274	4.52	2.532	2.444	0.088	2.50	2.25	0.495	0.436	0.436	0	7.91	2.25	0.000	5.758	5.05	643.5
CS17.06 - A	McGuireville TI - Option A (New Ramp)	239.25-239.75	5.85			0			0.000			0			0.000	3.228	1.12	61.7
CS17.06 - B	McGuireville TI - Option B (Replace Bridge)	238.75-239.75	18.32			0			0.000			0			0.000	4.320	2.24	52.8
CS17.07	Middle Verde Road Safety Improvements	NB 290-292	1.92	2.532	2.456	0.076	1.16	2.25	0.198	0.436	0.436	0	5.74	2.25	0.000	1.472	2.24	171.6
CS17.08	Dry Beaver Creek Southbound Climbing Lane	SB 292-294	9.35	2.532	2.532	0	1.76	2.25	0.000	0.436	0.435	0.001	5.61	2.25	0.013	0.091	2.24	2.2
CS17.09	Dry Beaver Creek Northbound Climbing Lane	NB 294-298	14.9	2.532	2.502	0.03	2.90	2.25	0.196	0.436	0.433	0.003	6.57	2.25	0.044	1.693	4.48	50.8
CS17.10	McGuireville Rest Area Safety Improvements	SB 295-298	2.83	2.532	2.451	0.081	2.72	2.25	0.496	0.436	0.436	0	6.09	2.25	0.000	3.594	3.36	426.3
CS17.11	SR 179 TI	299	4.97	2.532	2.477	0.055	1.88	2.25	0.233	0.436	0.436	0	5.09	2.25	0.000	1.714	1.12	38.6
CS17.12	Hog Tank Canyon Northbound Climbing Lane	NB 299-305	23.05	2.532	2.527	0.005	3.37	2.25	0.038	0.436	0.432	0.004	8.05	2.25	0.072	2.481	5.69	61.2
CS17.13	Hog Tank Canyon Southbound Safety Improvements	SB 300-302	4.52	2.532	2.439	0.093	3.09	2.25	0.647	0.436	0.436	0	5.36	2.25	0.000	6.738	1.90	282.5
CS17.14	Rattlesnake Canyon Safety Imptrovements	NB 306-307	2.15	2.532	2.450	0.082	2.21	2.25	0.408	0.436	0.436	0	6.17	2.25	0.000	5.288	0.95	233.0
CS17.15	Red Hill Scenic Overlook Safety Improvements	SB 311-313	6.33	2.532	2.490	0.042	3.68	2.25	0.348	0.436	0.436	0	5.33	2.25	0.000	1.244	1.60	31.5
CS17.16	Woods Canyon Climbing Lane	SB 316-317	5.65	2.532	2.530	0.002	2.52	2.25	0.011	0.436	0.435	0.001	4.54	2.25	0.010	0.129	0.81	1.9
CS17.17	Woods Canyon - Realign roadway	316.5 - 317.5	37.06	2.532	2.479	0.053	2.28	2.25	0.272	0.436	0.436	0	4.54	2.25	0.000	5.399	1.62	23.7

Appendix F

Project Prioritization Scores

Appendix F Project Prioritization Scores

Candidate Solution #	Candidate Solution Name	Milepost Location	Estimated Cost ($ millions)	Pavement		Bridge		Safety		Mobility		Freight		Total Factored Score	Risk Factors					Weighted Risk Factor	Performance Effectiveness Score	Prioritization Score
				Score	%	Score	%	Score	%	Score	%	Score	%		Pavement	Bridge	Safety	Mobility	Freight			
CS17.01	Table Mesa TI	236	2.37	0.000	0.0%	0.000	0.0%	0.006	0.3%	0.000	0.0%	2.329	99.7%	2.335	1.07	1.27	1.36	1.18	1.18	1.180	81.4	**96.1**
CS17.02	Black Canyon Hill Option A - Northbound Climbing Lane	NB 245-251	51.42	0.000	0.0%	1.745	9.9%	3.306	18.8%	6.113	34.8%	6.408	36.5%	17.572	1.07	1.27	1.36	1.18	1.18	1.223	608.6	**744.2**
CS17.03	Sunset Point TI	252-253	4.63	0.000	0.0%	0.000	0.0%	1.834	41.1%	0.385	8.6%	2.238	50.2%	4.457	1.07	1.27	1.36	1.18	1.18	1.254	285.7	**358.3**
CS17.04	Badger Springs Climbing Lane	NB 256-260	14.9	0.000	0.0%	0.000	0.0%	0.561	28.7%	1.372	70.3%	0.018	0.9%	1.951	1.07	1.27	1.36	1.18	1.18	1.232	71.1	**87.5**
CS17.05	Orme Rd Safety Improvements	SB 269-274	4.52	0.000	0.0%	0.000	0.0%	2.800	48.6%	0.997	17.3%	1.961	34.1%	5.758	1.07	1.27	1.36	1.18	1.18	1.268	643.5	**815.7**
CS17.06	McGuireville TI - Option A (New Ramp)	293.5	5.85	0.000	0.0%	1.092	33.8%	0.000	0.0%	0.000	0.0%	2.136	66.2%	3.228	1.07	1.27	1.36	1.18	1.18	1.210	61.7	**74.7**
CS17.07	Middle Verde Road Safety Improvements	NB 290-292	1.92	0.000	0.0%	0.000	0.0%	1.421	96.5%	0.029	1.9%	0.022	1.5%	1.472	1.07	1.27	1.36	1.18	1.18	1.354	171.6	**232.3**
CS17.08	Dry Beaver Creek Southbound Climbing Lane	SB 292-294	9.35	0.000	0.0%	0.000	0.0%	0.000	0.0%	0.091	100.0%	0.000	0.0%	0.091	1.07	1.27	1.36	1.18	1.18	1.180	2.2	**2.6**
CS17.09	Dry Beaver Creek Northbound Climbing Lane	NB 294-298	14.9	0.000	0.0%	0.000	0.0%	1.388	82.0%	0.294	17.4%	0.011	0.7%	1.693	1.07	1.27	1.36	1.18	1.18	1.328	50.8	**67.5**
CS17.10	McGuireville Rest Area Safety Improvements	SB 295-298	2.83	0.000	0.0%	0.000	0.0%	3.553	98.9%	0.024	0.7%	0.017	0.5%	3.594	1.07	1.27	1.36	1.18	1.18	1.358	426.3	**578.9**
CS17.11	SR 179 TI	299	4.97	0.000	0.0%	0.000	0.0%	1.661	96.9%	0.025	1.5%	0.028	1.6%	1.714	1.07	1.27	1.36	1.18	1.18	1.354	38.6	**52.3**
CS17.12	Hog Tank Canyon Northbound Climbing Lane	NB 299-305	23.05	0.000	0.0%	0.000	0.0%	0.115	4.7%	1.747	70.4%	0.619	25.0%	2.481	1.07	1.27	1.36	1.18	1.18	1.188	61.2	**72.7**
CS17.13	Hog Tank Canyon Southbound Safety Improvements	SB 300-302	4.52	0.000	0.0%	0.000	0.0%	6.307	93.6%	0.027	0.4%	0.404	6.0%	6.738	1.07	1.27	1.36	1.18	1.18	1.348	282.5	**381.0**
CS17.14	Rattlesnake Canyon Safety Improvements	NB 306-307	2.15	0.000	0.0%	0.000	0.0%	3.886	73.5%	0.500	9.5%	0.902	17.1%	5.288	1.07	1.27	1.36	1.18	1.18	1.312	233.0	**305.8**
CS17.15	Red Hill Scenic Overlook Safety Improvements	SB 311-313	6.33	0.000	0.0%	0.000	0.0%	0.870	70.0%	0.027	2.1%	0.347	27.9%	1.244	1.07	1.27	1.36	1.18	1.18	1.306	31.5	**41.1**
CS17.16	Woods Canyon Climbing Lane	SB 316-317	5.65	0.000	0.0%	0.000	0.0%	0.069	53.5%	0.060	46.5%	0.000	0.0%	0.129	1.07	1.27	1.36	1.18	1.18	1.276	1.9	**2.4**
CS17.17	Woods Canyon - Realign roadway	316.5 - 317.5	37.06	1.517	28.1%	0.000	0.0%	3.794	70.3%	0.036	0.7%	0.052	1.0%	5.399	1.07	1.27	1.36	1.18	1.18	1.276	23.7	**30.2**